A NUTRITIONAL AND ANTHROPOMETRIC ASSESSMENT OF MARSHALLESE SCHOOL CHILDREN

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Acknowledgements

Sitting down to write my acknowledgements gave me pause. I say this because it has been ten years since I began graduate school. In the autumn of 2004, I started a journey that I am not entirely sure how it would turn out. The entire process has been transformative and changed me as a person. The graduate school experience has been full of achievement, loss, and humility. I am a working class kid from Mars Hill, Indianapolis, Indiana. I was never supposed to be here. In the last ten years, I earned a master's degree and a PhD, forged lifelong friendships, saw love come and go, became a father, overcame struggles, and found that I could make learning my profession. I have recently been asked if I am proud of my accomplishment here. I was hesitant to answer that question. It was not because I felt a lack of pride in the moment. The pause present in my reply was because I know that I would have never gotten here without the multitude of people who have been there to teach and guide me. I can never forget the people who fed me or gave me a couch to sleep on when I couldn't afford much on a graduate student income. I will never forget the teachers and mentors who let me ask one more question because I just did not understand. I have a lot of people to thank here, but this will never repay them for the kindness, patience, and help they offered.

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gave me your time when you did not have it. Each of you listened when you were tired of hearing my ramblings. You pushed me beyond my perceived limits and made me a better person. You saw me grow up over the past ten to fifteen years. (Rick Ward was my undergraduate mentor). My life would have been drastically different if you were not a part of it and I have been lucky to have you guide me.

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Yokwe yuk.

Todd L Foster

A NUTRITIONAL AND ANTHROPOMETRIC ASSESSMENT OF MARSHALLESE SCHOOL CHILDREN

The study is a cross-sectional examination of growth and nutritional status among Marshallese school children living on Majuro Atoll. Colonialism and globalization have altered the foods available, economic structure, and historical social constructs of Marshall Islanders, especially those living on Majuro Atoll and these transitions have affected the growth and nutrition of the islanders. Anthropometric measurements were used to calculate nutritional status and body composition indices. The WHO 2007 child growth reference and Frisancho's Anthropometric Standards for the Assessment of Growth and Nutritional Status were used to explore the growth of Marshallese children. The sample consisted of 588 Marshallese children, aged 5 to 14 years of age, attending primary schools on Majuro Atoll. The overall rate of stunting among sampled Marshallese children was 34.6%. The rate of underweight children was less (8.2%) but this rate only reflects children aged 5-9 years due to the design of the WHO 2007 reference. This proportion of weight to height among the sample revealed body mass indices as "normal" when compared to the reference and the utility of body mass index among the Marshallese sample is brought into question. After exploring the rates of malnutrition among the entire sample, the anthropometric and body composition z-scores, as calculated in comparison to the references, of children attending public and private schools on Majuro were compared. The average z-scores for every nutrition and body composition measurement were statistically significantly higher in private school children. The study makes a particular focus on food, particularly with nutrition and food availability. Previous nutritional assessments in the

Marshall Islands compared to the present study finds no improvement in the rates of malnutrition despite localized efforts to address the issue. This study attempts to link the economic and nutritional transitions brought about by globalization occurring with Marshall Islanders over the last 150 years to the growth measures among the Marshallese population.

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Chapter 1: Introduction

In the summer of 2006, I traveled to the Republic of the Marshall Islands (RMI) with the assistance of an Indiana University Anthropology Department Skomp Summer Research Feasibility Study Award. I went to this country to explore the possibility of conducting a growth and development study on the effect of radioactive iodine (I-131) uptake in Marshallese children and adults. The Marshall Islands and the United States have an intertwined history reaching back to the end of World War II. Over a thirteen year period, the United States detonated more than 67 atomic and thermonuclear weapons on northern atolls in the Marshall Islands (Barker 2004). Some of the fallout from these weapons was absorbed into the soil of surrounding atolls and then incorporated through various routes into the food web, eventually making its way into the Marshall Islanders living there. Some of the atolls, inhabited or deserted, still reveal abnormally high levels of radioactivity to the present day (Barker 2004). Iodine is needed by various animals, including humans, in order to synthesize thyroid hormones, which are highly involved in the timing and regulation of human growth. Radioactive iodine (I-131) is absorbed in the diet just as normal iodine and has been shown to destroy thyroid tissues as well as cause cell mutations that can lead to cancer. Ironically, controlled doses of radioactive I-131 are used to treat some forms of cancer today.

During that summer, I spoke to a number of community leaders, government and health workers, and people in the community about this topic. A couple of disheartening things occurred that gave me pause. First, although the research was encouraged, a large research endeavor to show present day effects of the fallout would fall on deaf ears within the United States government. In 1986, when the Republic of the Marshall Islands became a country, the

United States admitted fault in the matter and paid the country 500 million dollars for any civil and infrastructure damage (Barker 2004). The Republic of the Marshall Islands lobbied for years to receive additional funding and assistance from the United States to clean up irradiated atolls, provide health care for islanders still suffering from ill effects, and continued research on the effect of the radioactive fallout. After a number of hearings and speaking engagements with the United States Congress, a court case in the summer of 2007 halted lobbying from the Marshall Islands. The United States argued the matter had been concluded with the money paid in 1986 and a United States court agreed.

Second, many Marshallese Islanders revealed a certain mistrust in an American they hardly knew asking about such a sensitive topic. These conversations did not arise until weeks into my living on Majuro Atoll, the capital of the Republic of the Marshall Islands. One night, weeks into the visit, a former mayor of Majuro sat with me drinking a beer at a local bar. During the conversation, the former mayor stated, “The bombs are a part of our history. It will always be a part of us and will probably always cause problems. But, if you really want to do something to help, just look around you. Children are malnourished. Adults in this country have one of the highest rates of diabetes and cardiovascular disease in the world. These problems are here and now.” This revelation led to a major change in research focus.

A week later, I attended a young professionals conference on Majuro Atoll. A number of presentations were given on issues and problems affecting the Marshallese and other Pacific Islanders. Networking and discussions occurred between me and other professionals. Two days after this conference, I received a call from one of those professionals asking me to come to the Ministry of Education to discuss a potential pilot study. During the meeting, numerous comments and observations were made by members of the Majuro community regarding the perceived difference in height and academics between children attending public and private schools in the area. Photographs from the local newspaper were shown to me highlighting these differences in height. The photographs were meant to acknowledge the academic achievements of the best students from both public and private schools on an annual basis. Members of the Ministry of Education present at the meeting quickly pointed out the public and private school children in these photos and the differences in height were readily apparent. Previous growth and nutritional assessment studies in the Marshall Islands, one in 1991 and another in 1999, led everyone to conclude that malnutrition was a problem among Marshallese children, especially among those living in urban settings, but the amount of recent data on this subject was limited.

The end goal for the Ministry of Education was to obtain data to support funding for a school lunch program at the public schools on Majuro Atoll. All private schools on Majuro Atoll offered a breakfast and lunch program, but the Ministry of Education did not have the funding to provide such a program to public school children. The meeting attendees learned that I was a biological anthropologist specializing in growth and development. They asked me to assist with the development of a pilot study obtaining and analyzing the data to support this end goal. The Ministry of Education hoped to obtain a rough idea of the prevalence of malnourishment in children living on Majuro Atoll as well as compare growth measures among public and private school children. As a result of this meeting, I agreed to undertake a study to examine the hypothesis that growth differences existed between public and private school children. I developed the study goals and measurements to be collected, helped design the study methodology, and committed to analyze the data and develop the final report. Due to the urgency of the need for the study, it was determined that others would collect the data so it could be gathered with speed and efficiency. I received the de-identified data for analysis in October 2006 and a government report was generated based upon these results. The results of this pilot study were also presented at the 2007 Annual Human Biology Association meetings (Foster et al. 2007).

The study was completed using 206 fourth graders attending public and private primary schools in the area. The number of children selected represented about 30 percent of the Majuro fourth graders enrolled in schools on the atoll in 2006. The Ministry of Education, along with Ministry of Health resources, wanted to choose fourth graders specifically because this age group was used in the last malnutrition survey from 1999 and all fourth graders in the Republic of the Marshall Islands take a standardized exam. The Ministry of Education wanted to not only examine differences in height and weight, but they also wanted to explore any differences in academic performance and school attendance. Children were selected from public schools in the communities of Ajeltake, Laura, Rita, Delap, and Uliga. Private school children were sampled from Majuro Cooperative and Assumption Catholic. The Centers for Disease Control 2000 growth reference was used to assess height and weight measures among age and sex of each participant.

The results revealed statistically significant differences among the public and private school children in average height-for-age, weight-for-age, and body mass index-for-age z-scores (females only). Public school children were, on average, below the mean of the reference population but private school children were much closer to it. The public school children's averages were significantly lower than the private school averages. The male private school students' average stature was statistically significantly different (lower) from the reference mean, but they were not different in terms of average weight or BMI.

Low weight-for-age can represent malnourishment acutely, or in recent time. Low height-for-age can tell a researcher or health worker something about the chronic, or long term, malnourishment occurring in and among children (Bogin 1988). Keeping these concepts of time in mind, it should be noted that the public school children displayed signs of malnourishment on both acute and chronic levels. Four children were identified as having severely deficient weight- and height-for-age and twenty-seven children were identified with moderate weight- and height-for-age malnutrition. The rates of malnutrition for height-for-age and weight-for-age, reported in Table 1.1, were also found to be statistically significantly different among the private and public school children sampled in this pilot study. The children from both public and private school systems revealed a large number of individuals as mildly undernourished. Sixty-eight percent of the public school children were categorized with mild, moderate, and severe stunting. In comparison, only thirty-six percent of the private school children in the sample were labeled with mild or moderate stunting. This huge disparity was found again when examining weight-for-age and classifying children as underweight. Children identified with moderate or severe stunting or underweight were noted and the Ministry of Health attempted to identify these children in order to take appropriate measures to improve their nutritional status.

Although the results of this study were beneficial to the Ministry of Education in securing funding to support a snack program (incidentally, this funding was discontinued a year later), a number of issues existed with the pilot study. The Ministry of Health provided the study team that collected data among these fourth grade children and there were some issues with their applied methodology. First, every child surveyed in the study self-reported their data, specifically their age. If a child was correct in stating their age, a whole year number was reported by the study team. The difference between a child aged 10 years and 30 days and 10 years and 360 days can alter the outcome of the individual assessment when compared to a growth reference. Second, the Ministry of Health research team did not use standardized anthropometric techniques in their data collection and the accuracy of the collected data could be suspect. Finally, the Ministry of Health research team did not complete any repeated measurements to determine the precision and reliability of their data collection.

In 2007, the World Health Organization (WHO) released an updated growth reference for children aged 5-19 years of age. This growth reference was developed as a reference that could be used to assess nutrition and health in children from developing countries. The CDC 2000 growth reference was developed sampling Americans throughout the 1990’s (McDowell et al. 2005). The researchers at the WHO felt that the current trends seen with the increase in overweight and obesity among these American samples may skew or misinterpret growth in populations living in developing countries. The development of the new WHO 2007 growth reference allows for an opportunity to reassess public and private school children in the Marshall Islands. Due to the methodological issues noted in the 2006 pilot study and the creation of this international growth reference (WHO 2007), I decided the pilot study was not thorough enough and that a more complete study needed to be conducted on Majuro Atoll. Two research hypotheses were developed for this study:

Hypothesis 1: There are no significant differences between the average height-for-age, weight-for-age, and BMI-for-age z-scores when comparing students attending Majuro primary public and private schools. Body composition measurement z-scores will reveal no significant differences between the two groups as well.

Hypothesis 2: Each of the groups sampled, public and primary school children, will not statistically significantly differ in their average attained growth measure z-scores when compared to the WHO 2007 reference population (deOnis 2007).

Testing these hypotheses allowed me the opportunity to assess the growth and nutritional health of Marshallese children as a whole as well. The first national nutritional assessment was conducted by Julia Alfred and Neal Palafox in 1991. The next exploration in child growth and nutritional health was conducted in 1998 by Joel Gittelsohn. Alfred and Palafox (1991) sampled Marshallese children, aged from birth to 18 years of age, as well as adults from various locations and atolls throughout the Marshall Islands. Gittelsohn's (1998) work was described as a pilot study touching on various aspects of growth and health and how lifestyle affects children and adults on urban and rural atolls throughout the Marshall Islands. Gittelsohn's work has allowed for more focused areas of research in the Republic of the Marshall Islands. Victoria Gammino (2001), a student of Gittelsohn, explored growth and nutritional health in children aged from birth to 5 years of age on Majuro Atoll, described as an "urban" atoll, as well as "rural" atolls in the Marshall Islands. My project builds upon and adds to this literature in a couple of ways. First, my project acts as a secular analysis of growth and nutritional health in the Republic of the Marshall Islands. A decade has passed since the last time children aged 5 to 14 years have been assessed. This project offers insight into whether interventions and attempts to address the malnutrition found in these previous studies has increased, decreased, or remained static. The focus of my project is placed on the "urban" environment and how growth and nutritional health may be different within this group classification. Although my study only focused on primary school-aged children, it does logically build upon Gammino's work. The second way this project plans to build upon the literature is to provide growth data that can be combined with Gammino's data in order to begin the process of developing a population-specific growth chart for Marshallese children.

This dissertation represents an updated nutritional assessment completed to address the methodological issues as well as expand on the sample size, age range, and geographic locations of participants on Majuro. A nutritional assessment was completed on the entire sample of children participating and then, returning to the original goals of the committee's pilot study, a comparison of the public and private school children was undertaken. The following provides brief synopses of the chapters in this dissertation.

Chapter 2 reviews the literature surrounding the history of the Marshall Islands with particular attention turning towards Majuro Atoll. This review then turns to the topics of human growth and nutritional assessment, the methods of anthropometry and its uses, and then considers the topic of growth reference data. The chapter concludes with a review of nutritional assessments conducted in the Pacific region with special emphasis on previous studies of this type conducted in the Republic of the Marshall Islands.

Chapter 3 covers the methodology used to conduct this study. The approvals required, recruitment methods, and data collected are highlighted here along with the specific means of comparing these data to reference data. In addition to anthropometrics, the data collection included a lifestyle questionnaire, personal health information for each participant, and participant observation. A discussion of measurement error concludes this chapter.

Chapter 4 explores the results of the nutritional assessment for all children surveyed in the study. This chapter reviews the use of the WHO 2007 growth reference, how body composition measures were analyzed, the verification of age, and the sample used to complete the nutritional assessment. A comparison of this nutritional assessment's results to historical assessments of Marshallese children is also presented. A brief comparison with the results of other Pacific Island assessments is also conducted.

Chapter 5 begins my comparison of children attending public and private schools. Additional methodology was needed to complete this analysis and that is described there. The participating schools are reviewed with some detail before discussing the results of this comparison. Further analysis was completed exploring nutritional status variation within the group classifications of public and private schools and this provided some very thought provoking findings.

Chapter 6 is an exploration of current Majuro lifestyle, dietary habits and food economics. This inquiry was completed with the use of historical literature on the Marshallese diet, interview data collected from a separate study initiated in the field, and the results of the lifestyle questionnaire previously mentioned. I also discuss the availability and types of food that can be found in grocery stores on Majuro.

Chapter 7 concludes the study by trying to present the "big picture" of how Marshall Islands children are growing and what the nutritional assessments indicate about this growth when compared to external reference data as well as internal subdivisions of the sample. I discuss the effects of nutrition transition, modernization and the concept of food deserts on the growth and nutritional assessment data. A recommendation for addressing malnutrition found among Marshallese school children is offered as well. This chapter also addresses limitations of the study and how the research builds upon previous growth and nutritional assessment research in the Marshall Islands. The chapter concludes with recommendations and directions for future research.

Chapter 1 Tables and Figures

Table 1.1: Rates of Malnutrition among Private and Public School Children on Majuro Based Upon the Pilot Study

	Mild	Moderate	Severe
Public (N = 163)			
Height for Age	39%	24%	5%
Weight for Age	26%	23%	4%
Private (n=42)			
Height for Age	31%	5%	0%
Weight for Age	26%	0%	0%

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Chapter 2: Literature Review

This chapter has two major sections for review. The first section introduces the reader to the Marshall Islands, including where they are located, their history with the outside world, and modern problems facing the Marshallese people. The focus eventually narrows to the capital atoll, Majuro, and what life is like there. The second section discusses human growth and nutritional assessment. A review of anthropometry and growth references occurs before discussing historical analyses in the Pacific. A particular focus on nutritional assessments conducted in the Marshall Islands concludes the review.

The Marshall Islands

Location

The Marshall Islands are located in Micronesia (Figure 2.1), across a large expanse of ocean extending from the southernmost sectors of Kiribati at approximately 7 degrees south latitude to the northernmost Mariana Islands at about 17 degrees North Latitude. The width of Micronesia stretches from Kiribati at 160 degrees West Longitude across the International Date Line to Palau at 145 degrees East Longitude. Located within this vast area are the Marshall Islands (Figure 2.2). The Marshall Islands are spread over 750,000 square miles of water and include 29 atolls and five islands consisting of more than twelve hundred separate islets, depending on the height of tide. Many islands are no more than seven feet above sea level, with the highest point about 30 feet. Some islands are as long as ten miles but rarely more than four hundred yards wide (Carucci and Poyer 2002). Majuro (Figure 2.3), the capital atoll, is over 30 miles wide. Marshall Island lagoons range from less than a mile to thirty miles across and as much as 75 miles long. The combined land area for the Marshall Islands, 70 square miles, is less than half that of the state Rhode Island (Kelin 2003). This vast amount of distance between islands and atolls is what probably led to Micronesian people being some of the finest seafarers in the world. The ocean is thought to be what links people together and Micronesians see the ocean as a road as opposed to a barrier. The abundance of birds migrating from island to island and the illumination of stars and their constellations assisted mariners in their travels (Carroll 1972, Hau'ofa 1993).

With the ocean being so vast and land being so limited, it is understandable why land might be highly valued. And with so little land, personal histories and identities would develop and attach themselves to a person's land holdings. Each atoll, geographically, has had its influence on how these social ties and organizations are created. Atolls with sparse land and small lagoons limiting the access to the sea were less likely to be chosen for development. The development of chiefdoms, which would include numerous specialized social roles and hierarchies, would not adapt well to the limited resources of these atolls. The historical ecology of an atoll, in the sense of whether it could provide resources and support large populations, guided the use and value tied to Micronesian Islanders (Carucci and Poyer 2002). The Marshall Islands lie north of the equator and have atolls consisting of coralline soils. Rainfall will decrease for six months of the year but will accumulate 50-100 inches per year on some atolls (Mason 1947). The location of the Marshall Islands leads to dry seasons with high winds half the year. Marshallese atolls lack the deep humus that allows many root crops to flourish and the land can be ecologically restrictive when compared to many other Micronesian atolls. These factors limit most of the crops to pandanus, coconut, arrowroot, squash, certain types of breadfruit, and, on occasion, dry-land taro. This array of staples can even be restrictive in latitudes or on atolls closer to the equator (Mason 1947). The restrictive nature of crop production though has historically led Micronesians to depend more on foods provided by the sea than the land. These factors have especially generated strong ties between Marshallese Islanders and their home atolls.

History

The Marshall Islanders are thought to have first arrived in these tiny islands between 500 and 2000 B.C., but there is some debate that permanent settlement did not occur until after 1AD (Carucci and Poyer 2002). Eight habitation sites on four atolls were test excavated and one radiocarbon age determination established occupation by 1260 $\pm$ 80 before present (Weisler 1999). Like other parts of historical Micronesian societies, Marshall Islanders are committed members of extended families and clans that are linked closely to the land on which they reside. Importance is placed on household and family commitments. Substantial communal sanctions keep one another aware that personal needs and wants do not outweigh those of the group. One's clan determines a person's essence and each person gets this clan identity through one's mother (Carucci and Poyer 2002). In contrast, it is thought that one's external features are shaped by, and transmitted through men. Lands are held by matri-clans. Residents will claim rights to reside on land through female relationships. The labor of the male members of each clan creates a continuity of identity felt throughout the clan and this relates back to the land as it is transformed by clan labor. An intimate relationship is created with the land. Marshallese Islanders work with, consume, and die on these lands and so their souls are thought to be tied with the soil. Land and people are thought of as being parts of a whole or one (Carucci and Poyer 2002).

Marshall Islands society also is divided into three caste systems that maintained the previously mentioned communal sanctions. These include Iroij, Alap and Rijerbal. The Iroij control land tenure, resource use and distribution, and dispute settlement. The Alap's responsibilities include overseeing the land and supervising daily chores. The Rijerbal carry out the daily work such as building, fishing, and collecting food (Kelin II 2003). Iroij are the chiefs of each clan and were once thought of as living deities. These chiefs were given the rights to oversee all of the lands of their domain and to adjudicate all disputes over those lands by the commoners who supported (nutritionally, politically, and militarily) their god/chiefs (Kelin II 2003). Historically, these caste systems did not necessarily carry any kind of disproportionate advantage as the Iroij would ensure that resources were distributed equally among all caste systems. They would ensure the delicate balance between the ecosystem and the islanders residing on their atoll. If this balance was unsuccessful or individuals took advantage of their roles, clans might rebel and warfare between clans would redistribute these caste systems to find a balance. The recasting of caste systems are said to have occurred until the advent of colonialism in the mid-to-late1800's (Carucci and Poyer 2002).

The Marshallese population has a long history of colonialism and a slow progression into a globalized society. In the 1840's, Spanish sailors started using the islands as a porting station and traded Western goods with the Marshallese to obtain materials and indigenous items to Micronesian Islands (Carucci and Poyer 2002, Hess 2004, Kiste 1994). This visitation also led Spanish missionaries to the area and Catholic stations were eventually established in the Marshall Islands. Protestant missions would soon follow. Judeo-Christian values and rules were slowly adopted within Marshallese culture and blended with elements of their historical ancestor worship.

In the late 19th century, German traders moved into the area and cleared whole islands of indigenous plants and animals in order to set up coconut plantations (Hess 2004, Kiste 1994). In many parts of the region, coconut is a core product because it was brought into prominence at the end of the whaling era as a new source of oil for European markets. By the 1860s, coconut oil production was widespread throughout Micronesia and would soon be replaced by the export of dried coconut (copra) for processing elsewhere. With the prominence of copra, many people came to think of coconut as the most important resource in their environment. Coconuts were used at every part of the developmental cycle as a food source. Marshall Islanders would adopt a focus increasing the production of coconuts on their islands in order to obtain Western goods (Carucci and Poyer 2002).

German explorers and entrepreneurs came to see Marshallese chiefs in European feudal terms (Erdland 1914, Kramer and Nevermann 1938). They depicted chiefs as the owners of the lands they oversaw and, with the emergence of the copra trade, chiefs and Alabs, their local land heads, were given new power as intermediaries in the production of coconut oil and copra. In German feudal interpretations, chiefs owned the land and the commoners were but surfs who lived under them (Mason 1947). Therefore, rank relations were considerably altered during this German copra era. With warfare outlawed through the adoption of Judeo-Christian values, late nineteenth century chiefly lines and castes became ossified. The introduction of European vessels, weapons, and supplies led to the expansion of chiefly domains, and the chief-commoner relationship became increasingly institutionalized along feudal lines (Tobin 1956).

Another result of these German plantations was that Marshall Islanders were introduced to a cash economy in exchange for their work to maintain these plantations. These wages allowed Marshallese to buy foods and goods in exchange for their time lost in subsistence activities (Pollock 1992).

By the beginning of the 20th century, the Marshall Islands were commonly accepted by the outside world to be owned by Germany. But by the end of World War I, Germany's interests in the Pacific were distributed between Japan and the United States. Both countries were assigned as protectorates to various Pacific Island populations. Japan was named as the protectorate to most of the Micronesian island populations. Yet, Japan saw the region as an expansion of its own limited territories where as German interests were primarily entrepreneurial and economic. Micronesians became citizens of the Japanese empire and Japanese citizens expanded into the area. For the first time, every young Marshall Islander attended primary school for three years and the best students were given opportunities to continue with higher levels of education, often attending a trade school in Palau. Students were taught Japanese and began to develop a sense of allegiance to Japan. Newly introduced domains of civil authority including local magistrates, police and civil clerks were established (Carucci and Poyer 2002). With the advent of World War II, many large public works projects initiated in the Marshall Islands were quickly turned into military facilities on Jaluit, Mili, Maloelap, Wotje, Kwajalein and Enewetak Atolls. Marshallese Islanders were forced to complete these military projects and suffered mistreatment and abuse by Japanese troops moving into the area. Marshall Islanders were considered "second-class citizens" in the Japanese empire (Carucci and Poyer 2002).

After WWII, the United States was named the protectorate of the Marshall Islands. The abuses of Japanese troops usually motivated Marshallese to welcome Americans as saviors and they viewed the United States as their "adopted" parent. The arrival of Americans brought the concept of freedom and altered the way Marshallese viewed themselves. However, this individualism is still something that Marshallese Islanders find conflicting with their historical emphasis on community (Carucci and Poyer 2002). During the Japanese era, many residents also recall the variety of foreign foods that were available on Jaluit Atoll. A large number of nineteenth century exchanges between explorers, entrepreneurs, missionaries, and local people commonly included foodstuffs (Carucci and Poyer 2002). During these pre-colonial and early colonial times, however, Micronesians were more often the providers of goods for European and Japanese markets. In contrast, in the American era, Micronesians were brought into exchange networks primarily as consumers. Food and types of developmental aid are among the principal exchanged items. In more recent times though, the local "product" of greatest interest to the U.S. has been Micronesia's strategic position, both as a pathway to the Japanese homeland during the second world war and as a buffer against perceived communist threats from the Soviet Union during the Cold War and then largely from China in the current day (Carucci and Poyer 2002).

This perceived buffer was only strengthened by the nuclear weapons testing in the Marshall Islands that the United States began in 1954. The United States used two atomic bombs in World War II, yet there was an accepted conclusion that the full effects of these weapons were largely misunderstood. In an attempt to further study the effects of nuclear weapons as well as display the power, the United States detonated 67 atomic and thermonuclear weapons in the air, on land, and in the seas of many of the northern atolls (Barker 2004). Thirty-three of these weapons tests had a greater yield than the largest atmospheric test conducted by the United States government in Nevada (deBrum 1999). As a result of this testing, many Marshallese were displaced from their homes and found themselves moving to atolls that offered safety, work, medical treatment and other family owned land (Barker 2004, Hess 2004, Carucci and Poyer 2002). This forced migration has caused a lot of strife among Marshall Islanders based upon their traditional ties to land and these struggles have been well documented (Barker 2004, Hess 2004, Niedenthal 2001, Kiste 1974). The establishment of testing grounds combined with the further development of former Japanese military bases led to urbanized areas on the atolls of Majuro, Kwajalein, Jaluit and Wotje. American military bases were an attraction for Marshall Islanders as jobs and Western foods and goods could be found there. Jobs, although limited in number, allowed many Marshallese to obtain a greater number of these Western imported foods and helped supplement their diets with the loss of access to local food items. In exchange for the use of land in the Marshall Islands, the United States entered into a Compact of Free Association that allowed Marshall Islanders free passage into the United States and qualified them for many of the social welfare programs available to American citizens. In 1986, the Marshall Islands became an independent nation while still maintaining the Compact of Free Association. The United States pays a fee to continue the use and function of military bases on Kwajalein and other locations in the Marshall Islands and much of this payment goes to the Iroij ruling over the land in use (Barker 2004).

Modern Contemporary Issues and Problems for the Marshallese

With the continued influence of the globalized world, each successive Marshallese generation tended to increasingly adopt Western behaviors and lifestyles in place of traditional ways of living. Traditionally, on atolls, land parcels typically ran from lagoon to ocean, with habitations concentrated along the lagoon shore and crop lands toward the ocean (Carucci and Poyer 2002). Many of the traditional methods of land use still continue on rural atolls, or the atolls that have not seen urbanization. As populations have increased beyond the productive capacity of an urbanized island, the need to maintain resource balance is no longer of concern. Many people have become dependent on outside resources, and some family members become specialists, holding government jobs, working in businesses, or providing specialized products for market. Access to a road or a local store may now be more important than the foods one grows on one's family land on these urbanized atolls (Carucci and Poyer 2002). Individual ownership and long-term land leases are a more recent application and many court battles occur between Marshallese arguing ownership of a parcel of land.

The allure of paying jobs in the urbanized centers finds many Marshallese migrating to these areas. The continued increase in population has brought a whole new set of problems to Marshall Islanders. The increase in population density and household crowding in the urbanized centers has seen a large problem with communicable disease transmission. In 2003, the Republic of the Marshall Islands experienced the largest measles outbreak within the United States or its associated areas for more than a decade, despite a reported vaccine coverage rate of 80-93% (Marin 2006). The outbreak ended only after >35,000 people were vaccinated. At the time, the population of the Marshall Islands was reported as 51,000 people (Marin 2006).

Diminished effectiveness was determined not to be the main cause of the outbreak though. Although efforts to increase immunization rates among Marshall Islanders have occurred, a more recent exploration of these rates on Kwajalein and Majuro Atoll has revealed quite variable vaccination coverage rates at 98% and 66.6%, respectively (RMI 2009). Bacterial diseases such as Typhoid and Cholera also continue to be a problem in the Marshall Islands. In 2000, Ebeye Island, the most populated urbanized area on Kwajalein Atoll, experienced an outbreak of Cholera that affected 400 of the approximate 11,000 inhabitants on Ebeye's 0.12 square miles, for an attack rate of 3.6% (Ahlgren 2007). The outbreak was connected to the handling and storage of contaminated water on Ebeye. Even I have experienced this issue with Typhoid on Majuro Atoll. My water catchment was tested twice in 2006 and Typhoid was found to be present, despite efforts to adequately chlorinate the water.

While residents of the typhoon-vulnerable outer atolls once and still do suffer from the risk of cyclical food shortages, urban islanders now are at greatest risk of an epidemic of "first world" diseases such as Type II diabetes, heart disease, high blood pressure, and hypertension. These illnesses are thought to be the result of colonially-constructed dependence on outside foodstuffs, correlating directly with the trend toward urban living in the government and economic centers of the region (Pollock 1992, Carucci 1997). Current day food staples include polished rice, granulated sugar, and bleached flour. High fat canned meats often complement these staples, and high fat cooking techniques are often the easiest option for urban islanders without access to firewood. Outer island residents, who blend imported foods with nutrient-rich local products, and who prepare foods in traditional ways, are typically less affected by diet-related health problems (Carucci and Poyer 2002).

Yet, an even more current issue is the concept of global climate change. As Rudiak-Gould (2013) notes, Marshallese are being told that climate change will erase their islands and this interpretation and an acceptance of the concept of climate change has been embraced. Marshallese Islanders are currently attempting to lobby major industrialized nations in an attempt to slow the progress of sea level rise. Despite the scientific evidence arguing for or against climate change, the evidence recorded in the Marshall Islands is present. Monitoring of sea levels in the RMI shows the continued disappearance of atoll land mass. The steadily rising oceans have led to the increased salinization of wells and the contamination of water supplies and ruining of crops. Along with the increase in tropical storms and flooding, Marshallese Islanders have accepted the reality climate change and the effect it is having on their daily lives.

Majuro

Other than Kwajalein Atoll, nowhere in the RMI is adoption of Western behavior and lifestyle more apparent than on the atoll of Majuro. Anyone first visiting Majuro expecting to find an untouched and pristine island setting is often quickly struck by the presence of the outside world. This point is well summarized by the anthropologist, Jim Hess, describing the first time he visited Majuro Atoll in 1992 (1994).

<u>Jim Hess Excerpt</u>

"If I ever desired to visit a remote corner of the world untouched by industrial civilization, here I realized that such desire would never be fulfilled. Immediately upon exiting the [airport] terminal, I am confronted by a parking lot full of Toyotas and Nissans, cars and pickups and vans mostly of Japanese manufacture. The material environment is decidedly unlike those images of thatched huts and grass skirts that romantic tales set in the Pacific bring to mind. Buildings are predominantly concrete or plywood and tin. Women usually dress in the long, loose dresses in printed fabrics introduced by Christian missionaries in the last century. Men generally wear dark-colored slacks and short-sleeved shirts. Unless on official business, both wear zories, plastic sandals held on by a strap across the toes. I look across the lagoon in vain for signs of the

slender and swift Marshallese canoes. Instead, I see small outboard motor boats, rusty fishing boats from Taiwan or other Asian fleets, and a few sailing sloops and cabin cruisers such as I would expect to find along the coast of California.

Having found a ride from the airport, located on the western side of Majuro Atoll, toward the urban center fifteen miles away on the eastern side, I pass houses, stores, restaurants, fields of grass and coconut palms, areas of bush, and the occasional church marked by a steeple or cross. There is the white and gleaming two-story U.S. ambassador's residence and embassy compound, surrounded by a fence. On the left I see the rusting remains of a freighter in the lagoon, later the generators of the Marshalls Energy Company. Most buildings are one or two stories; a few taller ones stand out. One is five stories of white concrete; it houses an FM stereo transmitter on the top floor, the antenna sprouting from the roof. Next to it is a construction largely of exposed steel beams and rebar, the relic of an ambitious undertaking by a Korean entrepreneur that failed while still under construction. A bit farther on I encounter a building that would not look out of place in Los Angeles, covered by panes of silvery reflecting glass. It is the new capitol building.

In the neighborhood of the capitol are other signs of connections to the outside world. Just down the road is Gibson's department store, extension of a company based in the U.S. territory of Guam. Here I buy groceries, kitchen utensils, computer supplies, and hardware. I pay with a Mastercard, manage my funds through the Bank of Hawai'i office which shares the building, and eat hamburgers and salads with 1,000 Island dressing in the café around the side. Toward the ocean from the capitol, across the baseball field, is the hospital, staffed by doctors from the Philippines, where I will get my teeth fixed by a dentist who spent the previous decade working on U.S. Indian reservations. Across the road is the 20 foot high concrete tower of the meteorological station maintained by the U.S. National Weather Service. Beyond the station is the blue tiled exterior of a resort hotel, still unfinished after ten years, begun by the island nation of Nauru with capital from payments for the phosphate mined there by the British. Down the road a bit are the radio dishes of the national telephone service, pointed at geosynchronous satellites, connecting to the United States through operators in Hawai'i.

Also standing out above the houses, shops, schools, and occasional palm trees are water towers, classic white cylinders with conical roofs, components in one of several water systems drawing on rain, wells, and the ocean… I pass churches and their schools which often have a small basketball court out in front. Down the road, on the right, the Catholic Church and school, run by American Jesuits, successors to German and Spanish predecessors. Next to it, the buildings of the College of the Marshall Islands, which has several hundred students in vocational-technical and liberal arts programs. Japanese volunteers whiz by on motor-scooters while many of the Peace Corps volunteers huddle around the entrance of their office a few hundred meters down the road.

Down the road another few hundred meters, the Mobil Oil tank farm sits behind a wire-mesh fence on the lagoon side. Then on the right, construction is beginning on a bowling alley. After it, an open lot in the middle of the island sits, which is unusual in this part of Majuro where there are usually two or three rows of houses packed into the fifty meters between road and beach. Then there are buildings of the courthouse and the museum, raised a story in the air by concrete pillars, protecting them from the waves that roll over the island every dozen years and *providing pedestrians welcome shade from the intense sun overhead. In the museum, only a few people walk through the room holding pictures and artifacts from the past exhibited as in Western museums. But there are always people at the tables below, watching the TV which endlessly plays videos of local dance and music, performance being the way islanders have preserved the past in an environment where artifacts rarely last.*

Past a church and a motel, there's the Kitco Restaurant. In later months I will stop by for broccoli-beef stir fry whenever I come in from a month in the outer islands with a craving for the vegetables, red meat, and fats missing from the usual diet of rice and fish. Next to it there's Charlie's Pub, which serves a good pizza. Then, another restaurant and a department store are located in one room with items running from thread and fancy underwear to sacks of concrete mix. Also here is the post office, zip code 96960, where you rent a box and collect your mail, when it is not held up in Honolulu waiting for cargo space on the next flight out. Here's Reimers' store, looking like a U.S. supermarket except perhaps for the chest freezer's bins of turkey tails and sheep flaps. Gibson's, partly own by the current President and Iroij, represents the economic success of the chiefs, based on capital initially accumulated through the copra trade and land rents. Across the road on the lagoon side are other components of the Reimers' organization, including an Ace Hardware store. Above it, the Tide Table restaurant offers a favorite hangout of ex-patriots. Behind the post office on the ocean side is the Marshall Islands Club, where I can listen to a local band and drink American and Australian beers while playing pool. It's owned by an Irish-American who came out as a Peace Corps volunteer and married a Marshallese woman, and with his Marshallese partner also publishes the weekly dual-language newspaper. A bit down the road, there's the cable TV station, feeding subscribers week-old programs shipped in from a San Francisco cable operator."

I can visualize most of this account upon reading it, despite my first experience in Majuro coming twelve years later. And like Hess (1994), my perceptions and expectations of Majuro were challenged similarly. Majuro is home to over half of the entire population in the Marshall Islands (Gammino 2001, United Nations Development Program and Economic Policy 2004). It is the capital atoll and is home to most government and administrative facilities. The population continues to experience rapid growth and this point is highlighted by a seven-fold increase in population from 1958 to 1999. In 2004, it is estimated that 28,000 people were living on the capital atoll (United Nations Development Program and Economic Policy 2004). This figure is alarming if you consider that the total land area of Majuro is 3.96 square miles stretching over 30 miles from east to west. The demographics of the Majuro population are of interest as well. The median age on Majuro from the 2004 census is 21 years. Although recent years have shown a steadily increasing age in the population structure, nearly 40 percent of the population is below the age of 15. The population on Majuro is primarily made up of Marshallese, yet it has seen a significant influx of several hundred Asian migrants over the last fifteen years (United Nations Development Program and Economic Policy 2004).

Majuro acts as a centralized location for the entire country for migrants, domestic and international. A domestic migrant is a term used by the Marshallese government to describe islanders moving from one atoll to another. Majuro is the highest receiving area of both domestic and international migrants. This fact is understandable considering the country's only international airport is located on Majuro (United Nations Development Program and Economic Policy 2004).

Development on Majuro has been primarily limited to the southeastern and eastern parts of the atoll, yet the central to western areas of the atoll have seen rapid residential development in the last decade. According to a Marshall Islands GIS report (United Nations Development Program and Economic Policy 2004), the average household size on Majuro is 7.5 persons with the most crowded area of Majuro being the community of Delap, with an average household size of 8.6 people. Most people living on Majuro own their home (87%) with about half of these owners (51%) having homes built on land through permission of the Iroij or Alab and the other half occupying land through traditional family rights. Ninety-three percent of households use electricity as their means of lighting and access to electricity can be found on nearly every portion of the atoll. This access is a stark difference compared to the rest of the country where some atolls do not have any or only minimal access to electricity or plumbing.

Only 38% of households cook with electricity though, whereas the rest of the Majuro population cooks with kerosene or firewood in a “traditional” cook house (United Nations Development Program and Economic Policy 2004). Traditional is a term used here as Marshallese sometimes describe a traditional cook house on their property even though it may include amenities not traditionally found in a cook house on rural atolls. Three quarters of households on Majuro have water catchments supplying water to their home (United Nations Development Program and Economic Policy 2004).

From my observations, many Majuro Islanders drive vehicles or ride in taxis on their way to work, to school, or other parts of the atoll. Grocery stores and restaurants offer multitudes of ethnic foods. Telecommunications (e.g. cell phones and the internet) are even available to those who can afford them. Despite this development on Majuro, not every islander is able to find a job and many find survival in a cash economy to be difficult. Many families rely on a few individuals to obtain enough money to support an average household of eight (United Nations Development Program and Economic Policy 2004). This urbanized lifestyle differs greatly from that on the rural atolls where there is no electricity, no running water, and non-indigenous foods are used only to compliment staples. Majuro was found to have a very low labor force participation rate at 43%, which means that nearly 60% of working age persons were unemployed and not looking for work (United Nations Development Program and Economic Policy 2004). For those listed as “looking for work”, an estimated 25 to 39 percent of workers were on file as unemployed in 2004. Of those who were employed, almost forty percent of them were employed by the public sector. The most popular jobs in Majuro are teachers, laborers, bookkeepers/cashiers, bricklayers, carpenters, construction, and policemen and security guards. The median household income is $14,737 a year. This same 2004 survey reported only six percent of working age persons on Majuro living a traditional subsistence lifestyle (United Nations Development Program and Economic Policy 2004).

This picture of economic activity and income among Majuro households leads one to understand that poverty is a real issue among islanders. Applying United States poverty thresholds to Majuro families reveals that the percentage of families below the poverty line is 80 percent and that number continues to show an increasing trend from previous surveys in decades past. In the 2004 national survey, over a third of households claimed that they sometimes or often did not have enough to eat (United Nations Development Program and Economic Policy 2004). Many of these households are located from Long Island (located between Delap and Rairok) to Woja (Figure 2.3).

According to Gammino (2007), only a fifth of Majuro households rely on local sources of protein and these households are primarily found in the rural areas of Majuro. These protein sources included fish, crabs, chickens, pigs, and clams. Likewise, only a third of households rely on local fruits and vegetables and again, this trend is seen primarily in rural areas. These crops mostly included coconuts, breadfruit, nin (coconut meat), pandanus, and bananas.

Sanitation and disposal of solid waste has also become a problem on Majuro. Landfills are inadequate due to soil and sand limitations. Direct discharge of sewage into the ocean may have contributed to the spread of infectious diseases, as was discussed earlier. The main source of drinkable water is from the rain, where households have their own catchment basin.

Growth and Development/Nutritional Assessment

"The health of a population is most accurately reflected in the growth of its children."

– Dr. Phyllis B. Eveleth (1990: page ix)

Anthropometry

Lasker (1994) states that "any aspect of physiological function depends on the underlying morphology, and the objective way of evaluating and comparing aspects of morphology is measurement." In the human that is anthropometry. Despite reservations some hold about past uses and abuses of anthropometrics, it can be seen that they are suitable and adaptable to many scientific and applied problems about human biology including changes over time in respect to growth or evolution, human factors in design of clothing and equipment, applications to forensic identifications, objective signs of physical fitness or illnesses, and the relative genetic and environmental components of variation of human anatomy under various circumstances including nutritional, immunobiological and other stresses. The trick is to adapt or design appropriate measurements that bear on the issues under study and use existing methods only if they are the most suitable or if they aid by permitting further use of already available information (Lasker 1994).

Anthropometry can be used to assess nutritional status at both the individual and the population level. Ideally, individuals should have several anthropometric measurements over time (i.e. a longitudinal study). A decline in an individual's anthropometric measurement or index from one point in time to another could be an indication of illness and/or nutritional deficiency that might result in serious health outcomes. In some situations, a single set of measurements may be used for screening populations or individuals to identify abnormal nutritional status and priority for treatment. This type of assessment, a cross-sectional study, allows for the comparative survey of children's growth among various populations and within the population as well. At the population level, the prevalence of low or high anthropometric indices can be assessed by determining the proportion of the population that falls below (or above) a cutoff value in a reference population.

In addition, the mean or median anthropometric value of a population can be compared with the reference value to assess the status of the study population relative to the reference population. "The average values of children's heights and weights are said to reflect accurately the state of a nation's public health and the average nutritional status of its citizens, when appropriate allowance is made for differences, if any, in genetic potential (Eveleth and Tanner 1990: 1)." Eveleth (1990) states that this is especially true in developing or declining countries and a well-designed growth study is highly useful in monitoring the health of a population or to discover sub-populations whose economic and social welfare might reflect their acute and chronic growth patterns.

One thing to keep in mind though is that not every population has the same growth potential. This statement reflects the understanding that large differences may exist in populations in terms of height or weight or the age at which puberty begins. A researcher must use discretion in understanding that these differences may either have their origin in genetics or factors within the environment or, more likely, both. There is still some debate about a standard growth potential existing among various populations. Some studies argue that the children of the majority of ethnic groups in the world can grow as well as international standards if they belong to elite socioeconomic groups (deOnis et al. 2006, Tomkins 1994). It is implied that children belonging to these groups would have minimal exposure to infection and their diets are adequate.

There are various techniques for anthropometric measurements and using these to measure growth and assess nutritional status. A number of publications describe techniques to measure children and adults and recommend specific tools or instruments to use. The three most commonly used volumes include the IBP Handbook or the Practical Human Biology Manual (Weiner and Lourie 1969, 1981), The Measurement of Human Growth (Cameron 1984), and the Anthropometric Standardization Reference Manual (Lohman, Roche, and Martorell 1988). These standardized techniques allow for measurements and assessment results to be accurately compared to future studies on the same population or compare, whether historically or presently, between different populations.

The preferred anthropometric indices for determining nutritional status are height-for-age, weight-for-age, and weight-for-height (more recently replaced by body mass index-for-age (BMI-for-age)), as these discern between different physiological and biological processes (Tomkins 1994, WHO 1986). Low weight-for-height or BMI-for-age is considered an indicator of acute undernutrition (thinness or wasting) and is generally associated with failure to gain weight or a loss of weight. Low height-for-age is considered an indicator of chronic undernutrition (shortness or stunting), which is frequently associated with poor overall economic conditions and/or repeated exposure to adverse conditions. BMI-for-age is also used to assess overweight and obesity. Weight-for-age is primarily a composite of weight-for-height and height-for-age, and fails to distinguish tall, thin children from short, well-proportioned children. But, the interpretation of seemingly disparate results for height-for-age versus BMI-for-age, can be facilitated by also knowing weight-for age (Jamison 1995). To calculate recommended anthropometric indices, information is needed on each individual's sex, age, weight, height, head circumference, and/or arm circumference. From these data it is possible to form different indices, including those that relate to height-for-age (HA), weight-for-age (WA), weight-for-height (WH), head circumference-for-age (HCA), body mass index-for-age (BMIA), mid upper arm circumference-for-age (MUACA) and mid upper arm circumference-for-height (MUACH). These indices can be expressed in terms of z-scores, percentiles, and percent of median relative to the selected reference population.

Anthropometrics may also reveal something about the composition of the body in terms of bone, muscle and fat mass. However, the calculation of body composition in children is much more difficult to assess compared to adults. A lot of attention has been placed on childhood obesity, but there is little information on total body fat. Data obtained from direct cadaver analyses are rare in children and indirect body composition analysis including underwater weighing, in vivo neutron activation, and potassium-40 counting is restrictive due to practical and ethical issues (Davies and Preece 1988). Detailed information regarding the growth of tissue compartments of the body, such as body fat, water, and lean body mass, is difficult to reveal using anthropometry. Changes in body weight do not tell much about the growth of individual tissues. Yet, there is recognition that the use of skinfold measurements to extrapolate measures of total body fatness, fat-free mass, and muscle mass, is a useful research goal. These estimates have problems and they are difficult to validate (Slaughter et al. 1988, Davies, Jones, and Norgan 1986, Martin et al. 1985). A major reason for this is that children are chemically immature and equations used to estimate body fatness in children use constants derived from adult samples. These equations may overestimate body fatness by 3-6% fat and underestimate lean body weight (Davies 1994). The problems are further highlighted by the change in chemical composition of the fat-free body as children pass through puberty. Slaughter et al. have addressed these issues by estimating body fat percentage through the use of total body water and bone mineral in addition to body density (1988). These estimations have further advanced with the use of bio-electrical impedance, which considers the body's total water content when measuring body fat (Slaughter et al. 1988). When considering the analysis of body composition then, the use of indirect techniques, such as anthropometry, are still utilized on children because of their non-invasive nature. Anthropometry considers the human body as a two-compartment model consisting of fat mass and fat-free mass. Fat-free mass consists of many different tissues including bone, muscle and viscera. So, although these estimates hold some potential error, they are the best solution for exploring body composition in children. The inclusion of measurements such as height and weight to these body composition assessments can further reveal estimates of nutritional status.

Growth References

For decades, health researchers, pediatricians, and nutritionists have used reference charts to track and assess the growth and development of children ranging in age from birth to 18 years. These references include data collected by the National Health and Nutrition Examination Study (NHANES) in 1971-1974, 1976-1980, and 1988-1994 (Frisancho 1990, Waterlow 1986), the National Center for Health Statistics (NCHS) in 1979 (Hamill 1977), the

Centers for Disease Control (CDC) in 2000 (Kuczmarski 2000) and the World Health Organization (WHO) in 1986 (deOnis 2006). Throughout the 1970's, '80's, and '90's, the WHO (deOnis 2006) recommended the use of the U.S. NCHS reference data as an international standard for comparison of child growth data. NHANES II and NCHS data sets were recommended for comparison when assessing data sets from populations from industrialized countries. There was some consideration that linear growth "deficits" found among developing countries were a reflection of differences in growth potential (Davies 1988). These differences expressed genetically-driven growth patterns, rather than environmentally-, and could be assessed in two ways. First, a researcher should consider the body size measure of children in a given age from industrialized countries with those of children from the highest socioeconomic groups from a developing country (which, in effect, controls for environmental factors) (Uliajszek 1994). Second, a researcher should examine secular trends in body size in the developing country to assess whether they had reached a plateau (Uliajszek 1994).

These continued issues of appropriateness of growth charts led many researchers in the 1990's to question the bias of the early NHANES and NCHS references, because they were based upon samples of children living within the United States and primarily reflected individuals with a middle class socioeconomic status and European ancestry (deOnis 2004d; Gorstein 1994; Kuczmarski 2000; Ulijaszek 1994). It was also argued that the methods used to develop growth curves for the youngest children (0 – 3 years) did not adequately represent early growth due to the fact that these references combined two different samples to develop the curve (deOnis 2004d).

These issues influenced the collection of updated information to create new reference charts. In 1999, the CDC/NCHS collected anthropometric data from a more diverse group of individuals, including both children and adults, in order to more accurately portray the average dimensions of children currently living in the United States (Kuczmarski 2000; McDowell 2005). This new data was added to the data collected from 1963 to 1994 to create the new revised growth charts for the United States (CDC 2000). This updated growth chart utilized improved data and statistical curve smoothing procedures to create the charts.

The WHO took the process a step further by assembling data from six countries including Brazil, Ghana, India, Norway, Oman, and the United States in order to develop a multicenter growth reference in 2006. This multicenter growth chart focused exclusively on birth to 5 year olds and included children from ‘‘diverse ethnic backgrounds and cultural settings’’ (Bhandari 2002; deOnis 2007; deOnis 2006:1-3) so that researchers could feel confident in applying the results worldwide. The inclusion of diverse ethnicities assumes that the WHO was sampling a variety of genetic backgrounds for the growth reference. As an added feature, this Multicentre Growth Reference Study (MGRS) only included children who developed in an environment where the researchers felt they could reach their full genetic growth potential. These guidelines included a socioeconomic status that did not constrain growth; epidemiological data showing low infant mortality; less than 5% prevalence of stunting, wasting, and underweight during the ages of 12 to 23 months; low altitude; low morbidity; a minimum of 20% of mothers willing to follow breastfeeding recommendations; and the absence of other health-related and environmental hazard issues (deOnis 2004b; deOnis 2004c). The rationale for this protocol was to develop growth reference charts that not only included an international database, but could also be used in a prescriptive manner (deOnis 2004b; deOnis 2006). Thus the WHO labeled this growth chart as a “standard” as opposed to a “reference”. It should be noted though that no Pacific Island or East Asian population is included in this “standard” of growth for children aged birth to 5 years.

The increasing awareness of childhood obesity among public health workers and the release of the April 2006 WHO Child Growth Standards for preschool children led many researchers to call for a single, universal, and appropriate growth reference for children, juveniles, and adolescents. Researchers do accept that using descriptive samples of populations that reflect a secular trend towards overweight and obesity to construct growth references may inadvertently result in an undesirable upward skewness, often leading to an underestimation of overweight and obesity, and an overestimation of undernutrition in many samples. In other words, the secular trend of increasing weight among Americans designs a reference that is inappropriate among non-American populations. The reference previously recommended by WHO for children above 5 years of age is the National Center for Health Statistics (NCHS/WHO) international growth reference. This reference has drawbacks in that the body mass index-for-age reference, which was developed in 1991, only starts at 9 years of age. It also grouped data annually and covered a limited percentile range. Researchers needed to have body mass index curves that start at 5 years of age and permit unrestricted calculation of percentile and z-score curves on a continuous age scale from 5 to 19 years of age.

In regard to 5 to 19 year olds, the WHO MGRS research team eventually came to the conclusion that selecting these children and adolescents from different countries would not accurately portray growth and development because the effects of the environment would weigh too heavily on their growth trajectory. Even so, the research team still attempted to gather reference data collected from multiple countries and found that the methodologies strongly differed and combining the data, in their opinion, would not yield an accurate assessment of growth and development. The research team finally decided to stick with the original 1977 NCHS data set and reconfigured the growth charts using updated statistical procedures to find the best fitting growth curves (deOnis 2007). This method, known as the Box-Cox Power Exponential, is described as a better method for taking skewness into account and finding commonality in smoothing a regression line (Cole 1992; Green 1992; Stasinopoulos 2004). The procedure was used with the 1977 data set to compile a growth reference for children aged six to eighteen years old. This updated growth chart was then combined with the MGRS standard to create a single growth trajectory (0-18yrs.) for research, analysis, and assessment (deOnis 2007).

The CDC 2000 and WHO 2007 growth references are the most current references and are the most appropriate for nutritional assessment in current studies. Our dilemma is in considering which one of these growth references to use for the assessment of Marshallese school children. A number of studies have considered the differences in nutritional assessment results when applying both the CDC 2000 and WHO 2007 growth references to their data (Twells and Newhook 2011, Kovalskys, Herscovici, and Gregorio 2010,Tuan and Nicklas 2009). These studies, along with a number of others, have found consistent differences when comparing the results of both references. The CDC 2000 tends to *over-report short stature* rates and *under-report rates of overweight and obesity* when compared to the WHO 2007. This point is especially true for children aged 6 to 10 years. An unpublished study completed by myself, a colleague and our mentor found similar results comparing the outcomes of a developing and a developed population (Foster, Roditis, and Jamison 2011). Our recommendation is that researchers working with populations in transition, where undernutrition is of great concern, should choose the WHO 2007 reference as a more conservative choice in assessing growth data. The WHO 2007 reference will not identify more children as stunted or overweight, but it will more accurately identify these children at risk of stunting and underweight.

It is for these above-mentioned reasons that the current study utilizes the WHO 2007 reference to assess Marshallese growth and nutrition. The height-for-age and BMI-for-age charts extend to 19 years of age. The weight-for-age charts extend to 10 years of age for the benefit of countries that routinely measure only weight and would like to monitor growth throughout childhood. According to the authors at the WHO, weight-for-age is inadequate for monitoring growth beyond childhood due to its inability to distinguish between relative height and body mass, hence the provision recommended by the WHO and as it is applied here (de Onis et al. 2007). BMI-for-age will complement height-for-age in the assessment of thinness (low BMI-for-age), overweight and obesity (high BMI-for-age) and stunting (low height-for-age) in school-aged children and adolescents.

Previous growth and development/nutritional status studies of Pacific populations

Geography alone is often the reason for grouping inhabitants of the Pacific Islands together. Considering cultural behaviors and biology though, there are a number of differences within and among Polynesians, Melanesians, and Micronesians. Often, natives of Australia are also grouped into this classification. The historical migrations of these people, as explored through archaeology, linguistics, osteology and population genetics, highlight the similarities and differences among these peoples (Matisoo-Smith 2015, Duggan et al 2014, Corser et al 2012, Kayser 2010, Friedlaender et al. 2005, Friedlaender et al. 2002, Kirch 2002, Houghton 1996, Diamond 1988, Tyron 1985). The majority of evidence suggests two large waves of migration out of Southeast Asia occurred at 50,000 and 4,000 years before present (Friedlaender et al. 2002). The dating here is constantly challenged or updated with the continued study of dating techniques within archaeology and population genetics. The evidence presented by population geneticists is that there was never a cessation of new genes into near and remote Oceania, but these major waves of migration brought two major haplotypes that are prominently displayed among Pacific Islanders today (Matiso-Smith 2015). The distinction of near and remote Oceania is a different classification scheme from Polynesians, Melanesians, and Micronesians. Near Oceania includes a majority of the island groups in the Melanesian classification such as Papua New Guinea, the Solomon Islands and the Bismarck Archipelago, a sub-division of islands off of the Eastern coast of Papua New Guinea. Remote Oceania includes the islands north, south, and east of these aforementioned Near Oceania island chains (Kirch 2002). The introduction of “foreign” genetic admixture into a Pacific Island population has been continually occurring since the first migration into the area. This admixture was usually due to Pacific Islander males as trading, warfare, and exploration were generally male activities among Pacific Island populations. The matrilineal family lineage practiced among a majority of Pacific Islanders was probably influenced by these male activities as males were continually lost to the sea or were never able to return to their home islands (Friedlaender et al. 2002). There is a large amount of literature discussing theories about how this third of the globe became populated, but our continued focus here is on anthropometry and its use to explore nutritional assessments and growth and development of these peoples. This point being made, it should be remembered that Marshallese Islanders most likely share a common growth potential with other Micronesian Islanders. This commonality in growth potential is shared less with Polynesians and even less than that with islanders from Melanesia. Further introduction of genetic admixture into the Marshallese population with Europeans in the late 19th century and Japanese and Americans in the 20th century may further affect the growth of Marshallese in comparison to other populations. This section will maintain a focus on growth and nutritional assessment in the Pacific at large and eventually narrow down to assessments conducted in the Marshall Islands.

Studies of growth and nutritional assessment have been completed in a number of island populations in the Pacific. A group of researchers in Perth, Australia have explored the growth and nutritional status of Australian Aborigines in the Kimberly region of Western Australia. They found that the people live in a wide range of conditions, from remote, partly tribal communities to partly urbanized groups outside of country towns. This difference in living condition has been noted by the authors to explain differences found in growth measures among school-aged children (Gracey et al. 1983, 1984, Gracey and Sullivan 1988, Hitchcock et al 1987). The impact of differences in living conditions on growth has also been noted among the Bundi of Papua New Guinea. This growth study was part of a larger study of health and nutrition in villages and urban areas by the Papua New Guinea Institute of Medical Research (Zemel and Jenkins 1988). In fact, a number of growth studies have come out of Papua New Guinea. Data exists from Pere village on the island of Manus as well as two studies on the Mountain Ok-speaking people of the New Guinea highlands (Lourie et al. 1986, Schwartz, Brumbaugh and Chiu 1987). The first mentioned study provided baseline data on the Wopkaimin Mountain Ok of the Ok Tedi region of the Star Mountain in the Western Province and the second study on highlanders living in the West Sepik Province. The Harvard Solomon Islands Expedition (Friedlaender 1987) has also completed a report examining Micronesians and Melanesians living in and around Bougainville, Solomon Islands. Again this study highlights the cultural and ecological differences among the sampled groups. These differences were expressed as modernized versus traditional living patterns.

Samoan populations have been studied extensively by Paul T. Baker and his team of researchers from Pennsylvania State University. Their studies have focused on the effects of modernization and migration on health. Their work focused on three specific populations of Samoans. These included rural villages in traditional Western Samoa, villages on two islands in American Samoa, and urban and suburban communities of Samoans living in Oahu, Hawaii (Baker 1984, Bindon and Zansky 1986). Slow reversal in the prevalence of communicable to non-communicable diseases, as well as increasing rates of obesity and high blood pressure among Samoan children were observed as modernization increased (Baker, Hanna, Baker 1986). Despite pre-existing excess adiposity, longitudinal data also indicates that Samoans continue to gain weight and body mass indices continue to increase in average measurements of children and adults. Another study conducted by this team in 1982 found that the consumption of fat from imported foods increased the risk of obesity and diabetes among Samoan adults by 2.2 fold and 2.4 fold, respectively. They noted that salaried sedentary jobs were becoming more common and a dietary shift from locally produced fruits and vegetables to imported processed foods was common place among Samoans and American Samoans.

Samoans are experiencing some of the highest prevalence rates of obesity and associated negative health conditions in the world. Another study conducted in 2002 and 2003 explored the association between farm work and adiposity among adults residing in American Samoa and Samoa (Keighley et al. 2006). Adiposity was measured by body mass index and body fat percentage. Regression models adjusted for the effects of age, education, occupations and material lifestyle, and the clustering within households. As the researchers expected, farm work was associated with statistically significantly lower body mass indices and body fat percentage in men of all ages residing in American Samoa and Samoa (Keighley et al. 2006). In 1960, the primary occupation on Tutuila, the main island of American Samoa was agricultural worker. By 1974, only 8% of economically active males were still involved in farming or plantation work (Greska and Baker 1982). By the 2000 census, only 7% of all adults in Samoa did primarily subsistence work. The authors continue to argue that modernization has profound effects on the way of life, biology and health of Samoans. As Keighley et al. (2006) has noted, Samoans are not alone in this rapid transition, with obesity becoming widespread in the region. Eight to ten percent of all deaths in the Pacific region were attributable to obesity (WHO 2000).

Another study of Polynesian migrants focuses on Tokelauan Islanders living on Tokelau and those who have migrated to New Zealand (Ramirez and Mueller 1980). Principal components analysis was used to study the amount and bodily distribution of subcutaneous fat in Tokelau Island children living on Tokelau and those whose families who had migrated to New Zealand ten years prior to the study. The study children were aged 5 to 17 years. Tokelau children who migrated to New Zealand were not only more obese but their fat had also shifted away from the extremities and towards the trunk, as compared to children in the Tokelau Islands. The migrant-island differences appear greatest in late childhood and adolescence.

The growth studies reviewed thus far present summary data among child and adolescent age ranges. The data from these studies will be discussed again in chapter 4 allowing comparisons to be made with the Marshallese sample from this dissertation. A number of other nutritional assessments have been made in the Pacific, but we will draw more of a focus on studies conducted in Micronesia or including Micronesian Islanders from here. These studies report on rates of stunting and wasting as determined by comparison with the National Center for Health Statistics/World Health Organization reference.

A study on Palau (Pobocik et al. 2000) explored the diet and body composition of a small sample of pregnant women (n=27) and their children (n=32). Twenty-four hour dietary recalls were collected among both groups. Seventeen anthropometric and body composition measurements were collected from the pregnant women and 28 measurements were obtained from children. The dietary recalls found diets to be low in calories, calcium and zinc. Micronutrients consumed by children were obtained from fortified grain products and milk. The energy consumption distribution was higher in proteins and fat and lower in carbohydrates than earlier reports of adult Palauans (Pobocik et al. 2000). Although infant and child cohorts were small in this study, their findings indicated that a relatively high proportion of these younger children were experiencing inadequate growth. This was especially true with females, among whom stunting and wasting, as determined from weight and arm circumference measurements, were more frequent in the sample. The majority of anthropometric measurements and associations with this diet revealed that these women and their children were experiencing inadequate growth and development when compared to the NCHS reference (Pobocik et al. 2000).

Another study (Cavalli-Sforza et al. 1996) of interest involves cross-sectional data from multiple islands in Palau. This study sought to evaluate nutrients in the diet along with anthropometric measurements among Palauan children and adults. Nutrient evaluation was completed using the Food Intake Analysis System developed by the University of Texas Health Science Center. Anthropometric measurements on children in the study included height, weight, sitting height, seven trunk and limb circumferences, six skinfold thicknesses, two trunk breadths, total arm length, and seven cephalometric measurements. The nutrient evaluation found, like the other Palauan study discussed above, that diets for adults, as well as children, were low in calories, zinc, and calcium. Fifteen of the 31 (48%) infants and children surveyed in this study had weight-for-age values under the NCHS/WHO 5th percentile. Six of 23 (26%) of the children surveyed were under the 5th percentile for the reference. Unlike other previous studies, mid-upper arm circumference (MUAC) was explored as well. The MUAC-for-age for this group of surveyed children was described by the author as presenting an intermediate group profile, with 18% of the children having values below the NCHS/WHO 5th percentile. The authors argued that the results of the survey among children, as well as the adults not discussed here, were probably a reflection of a combination of social, cultural and genetic factors. They determined that socioeconomic status was a major determining factor, as most Palauan families were not affluent (Cavalli-Sforza et al. 1996). This study, along with the one discussed by Pobocik (2000), is of particular interest to us as these are the first nutritional assessments discussed here to look at a population relatively close to the Marshall Islands.

Although these two island populations are separated by over 4,000 km, Palauans and Marshallese are Micronesian and share similar linguistics, social behaviors, and physical characteristics.

One more nutritional assessment deserves mentioning here. It will also allow an easy transition to Marshall Island focused studies. The following assessment examined multiple populations throughout the Pacific, including small samples of Marshall Island children. This was conducted in 1997, by a WHO survey team visiting American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Kiribati, Marshall Islands, Nauru, Niue, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu (Hughes et al. 2004). The goal of the study was to determine the prevalence of roundworm and hookworm infections, which can lead to a physiological disease known as helminthiasis. They also examined the nutritional status among Pacific Island school children. The study surveyed 3,683 children aged 5 to 12 years of age. These children attended 27 primary schools in 13 Pacific Island countries. Summary results were given for the children as a whole, but the report gives statistics for each Pacific Island population surveyed. Of particular interest here are the results found from the Republic of the Marshall Islands. The researchers visited Majuro Atoll and surveyed children from two different schools. These included Rita and Laura elementary schools. The Rita sample included 56 boys and 43 girls. The Laura sample included 85 boys and 88 girls. The Rita sample revealed 28 of the children had a helminths infection (83.3% of the boys, 70% of the girls). The Laura sample found 92 of the children sampled had a helminths infection (91.5% of the boys, 75.6% of the girls). The nutritional assessment results of these Marshallese children are also presented. The Rita school sample revealed a stunting rate (height-for-age z-score < -2) of

25.3% and an underweight rate of 8.1%. The Laura school sample had a stunting rate of 32.5% and an underweight rate of 16.3%. No children from either school had a body mass index-for-age z-score greater than +2 z-scores, the cut-off for classification as "overweight" (Hughes et al. 2004).

Marshall Islands

The discussion of nutritional assessment among Marshallese children in the WHO study above is one of the few surveys to explore nutrition among Marshallese children. Less data exist from Marshall Islanders when compared to other regions. This previously mentioned study, along with three other notable studies reviewed below, are the only explorations of growth and/or nutritional assessment that have been completed in the Marshall Islands. It is here where I shall take a more in-depth look at previous growth studies and nutritional assessments of children the Marshall Islands.

As stated earlier, the Marshall Islands officially became an independent country in 1986 (Barker 2004). The creation of government and institutional structures led to the first national nutritional survey in 1991. This survey was conducted by Neal Palafox and Julia Alfred (1991), the now current Secretary of Health, with the assistance of UNICEF. It not only focused on nutritional assessment, but also produced a census and noted a number of pilot studies examining health and social issues among Marshallese adults and children. In 1991, the total population of the Republic of the Marshall Islands was noted as 43,380 people with an estimated growth rate of 4.2% a year. At the time, more than half of the population was reported as below 15 years of age. The reported infant mortality rate was 63 out of 1000 live births and life expectancy was 57 years for males and 63 for females.

This 1991 national nutritional survey was prompted by a couple of earlier reports from the hospital located on Majuro Atoll. In 1983, malnutrition accounted for 7% of the total deaths among 1 to 4 year olds, while 17.8% of total childhood deaths were attributed to malnutrition. Over a three year period (1987-1989), 11.4% malnutrition prevalence was noted among 0-5 year old children visiting the hospital (Alfred 1991). In 1989, a report from the RMI Ministry of Social Services reported that a Nutrition Surveillance Program funded by UNICEF in 1987 found that 10% of preschoolers surveyed were moderately and severely malnourished. There was 35% and 8% prevalence of undernutrition and overnutrition, respectively, among 6 to 14 year old children (Alfred 1991). Table 2.1 displays these malnutrition rates along with the rates discussed in all of the Marshallese nutritional assessments reviewed here.

The first nutritional survey was conducted with an emphasis on improving and ensuring the welfare of children and so focused heavily on women and children. It was conducted in September of 1990 through May 1991 with the continued assistance of UNICEF funding and health workers. The report states that it aimed to describe the nature, extent and causes of malnutrition among children aged from birth to 14 years old and women aged 15 to 49 years. The report also explored family characteristics, activities and conditions, and makes recommendations on actions to support child survival and safeguard children's well being. Over 660 households in 33 clusters throughout the Marshall Islands were surveyed with over 5,000 participants taking part in the study (Alfred 1991).

The study collected a number of types of variables including anthropometrics, biochemical assessment data, and dietary assessments. Weight was collected using a calibrated clinical beam balance scale. Each weight measurement was taken with the participant wearing minimal clothing, empty pockets, and no shoes, belt or headgear. Height was measured using the sliding measurement scale located on the beam and balance scale. Participants were asked not to wear shoes and the report notes use of the Frankfort horizontal when measuring height. Mid-upper arm circumference was also collected, but no skinfold measurement results are noted. Anthropometrics were assessed using the NCHS/WHO reference. Growth measures were only monitored in 36% of the sample which accounted for approximately 629 children. Of these measured children, 38% or approximately 239 children were sampled from Majuro.

Biochemical assessment included hemoglobin determination, fasting blood sugar, and overall assessment. Hemoglobin was measured using a portable BMS hemoglobinometer. Fasting blood sugar was determined using a glucose test strip. Overall assessment of each participant was completed by a health worker who palpated organ systems to evaluate liver and spleen enlargement. The health worker would also make an overall judgment regarding muscular wasting and edema occurring in the individual. These findings were either recorded as positive or negative. Any cases of frank anemia, xerophthalmia and protein-energy malnutrition were referred to local health workers.

Dietary assessment was based on an appraisal of the household and asking the matriarch to complete a questionnaire. This questionnaire evaluated the amount of food usually eaten by the family using household measures and the manner of its preparation. In particular, it would inquire what types of food were being consumed, the serving size of food items, and the frequency of intake per meal. The questionnaire would also inquire at what age food items were first given to children or infants in the household. These questionnaires were then used by the assessment team to evaluate the following items for each household: the cost of food items consumed; the total calories, proteins, fats, carbohydrates, iron and vitamin A content of foods eaten per meal using the Food Composition Table for the Pacific; the total amount of nutrients per household by dividing the number of household members to get the per capita intake by nutrient and food groups; and computing the percentage of calories, proteins, vitamin A and iron derived from energy giving, body building and body regulating foods.

This questionnaire found food habits including a breakfast, lunch, and dinner pattern in the majority of houses, but in some, a late morning and/or afternoon meal was consumed. Breakfast generally consisted of bread, rice, or cooked breadfruit, some fish or meat or just a sweetened drink. Soft drinks were a common drink by children and adults at any time of day. The lunch and supper meals showed similar components as the breakfasts. Fruits and vegetables were seldom eaten because of scarcity in the community and high cost. Pandanus, banana, and papaya are the only locally grown fruits, while beans and tomatoes are locally produced for cash income (Alfred 1991).

The questionnaire also found that nutritional intake and consumption reflected the individual family and was dependent on the household's capabilities in obtaining adequate quantities of food, either by their own levels of food production or their purchasing power. Big households reflect the Marshallese custom of extended family systems; seldom or rarely could anyone find a nuclear family setting in this survey. Fifteen percent of the households surveyed had no one with a wage paying job. The average food expenditure for households was about ten dollars a week and a quarter of all households depended on two dollars per week or less for food. The authors do point out that this is quite different on Majuro and Kwajalein Atolls where a half to two-thirds of the household income was spent on food. Outer island households were more dependent on their own grown crops, sea catches and livestock for consumption, not to mention the other sources of food obtained if they were traditional leaders or Iroij (Alfred 1991).

As this study was quite extensive and our focus is on Marshallese children, I only review the findings of dietary habits and anthropometric results for the “Pre-School” children aged birth to 7 years and “School-Aged” children aged 7 to 14 years of age. My review begins with the “Pre-School” children. The survey found that breastfeeding occurred in 85% of children up to 6 months of life and in more than 60% of the children up to one year of life. Breastfeeding was noted to decrease to less than 20% of the children by the second year. Infants were often given a mixed feeding of breast milk and solid foods after the fifth month of life. More than half of the children surveyed were eating solid foods by 5 months of age. Formula feeding was found to be irregular (less than 50% of the households surveyed), and of those who did feed formula to their babies rarely did they do so after 9 months of age. By 12 months of age, local baby foods including porridge, mashed pandanus and breadfruit were introduced along with imported baby foods, cereals, eggs, milk, cheese, fish and meat, sugared/soft drink, sugared snacks, chocolates, and fats/oils. The survey also revealed that almost all of the pre-schoolers had breakfast, lunch and dinner on a regular basis, but only half of them had snacks available (Alfred 1991).

Out of all the pre-school children sampled, only half of 2 year old children were completely immunized and five percent of the pre-school children had a current or recent episode of diarrhea. Overall, a fifth of pre-school children were noted to have dry, thin and sparse hair as well as dyspigmentation of the skin. The loss of subcutaneous fats, wrinkling of the skin and muscle wasting was noted in about a fifth of the children examined as well. Twenty-four percent of the pre-schoolers sampled were classified as stunted based upon the NCHS/WHO reference. The anthropometric measurements also revealed that one out of every five preschoolers (20%) was considered moderately to severely underweight based on the WHO cut-off of 80% standard weight-for-age. Mild underweight was noted in 36% of the pre-school children under study as well. Overweight was only observed in 8% of the preschoolers measured. Overall, the investigators in this study found that deviations from the standard or reference started to manifest at six months of age. A high prevalence of moderate to severe underweight was observed at one to two years and at six years of age. Among these malnourished children, a large number of them were noted to have anemia and vitamin A deficiency (Alfred 1991).

The results for “school-aged” children in this study were not as extensive as those of the “pre-school” children. The coverage of growth monitoring in this age group was poor and the authors suggested that it may be due to the migration to urban communities or to the neighboring atolls/islands. They did not report actual numbers of sampled children for the “school-aged” category. A majority of school-aged children were found to be anemic and had to be given iron supplementation. This prevalence was especially high among 13 and 14 year olds. The prevalence of anemia among school-aged children signifies that they have a characteristic diet low in protein and iron-rich foods. Fasting blood sugar levels were found to be in the normal range for most school-aged children with only a small proportion of them presenting with slightly higher than normal values (Alfred 1991).

Thirty-five percent of school-aged children were classified as stunted. This was especially true among children aged ten to fourteen years of age. The researchers suggested that the gradual and longstanding deprivation of nutrients throughout childhood and at earlier ages have resulted in a long process of growth retardation. The larger percentage of stunting among this group may be complicated by the normal age dependence of growth velocity (Alfred 1991).

Examining the weight-for-age of this group, 40% of the school-aged children surveyed were classified as moderately to severely underweight. School-aged children, especially those aged 7 and 11-13 years, were some of the most effected groups of malnutrition. One in every five 7 year old children was moderate to severely malnourished. This high prevalence of undernutrition may again reflect weight deficits caused by previous undernutrition and other non-nutritional insults that continued to accumulate from a younger age. The authors did point out that weight deficits here cannot discount the possibility of smallness among these children. Low weights could be attributed to the increasing energy requirements during the periods of growth spurts as well as an increased energy expenditure at work and play. They also point out that children in this age group were more choosy and selective of their foods and the children who exhibited weight loss may have had individual differences in the ability to absorb and utilize the actual nutrient contents of food (Alfred 1991).

Another notable finding among this age group was the estimated onset of menarche among Marshallese females. The researchers concluded that the average age of menarche occurred at 12.3 years, and the range was from 10 to 16 years of age. The authors noted that in developed countries, the range was from 10 to 13 years with an average at 13 years (Alfred 1991).

The authors concluded that nutritional status seems to react to the accumulating effects of household size, income, education, per capita intake, food expenditures and feeding patterns. Although not fully discussed here, among 15 to 49 year olds, more than half of them were obese and 25% in this age group were suffering from type II diabetes mellitus, especially among women. Pulmonary tuberculosis and hypertension were also prevalent as major chronic health problems along with STDs, alcoholism, high suicidal rates and early pregnancy affecting this age group as well. Among children, both pre-school and school-aged, protein-calorie malnutrition, anemia, and vitamin A deficiency were the major nutritional disorders in the Republic of the Marshall Islands. The authors felt that the ecology of malnutrition could be traced back to Marshallese tradition, where a child was breast-fed for two years while solids were introduced as supplement after the child reaches one year of age. It was thought that these introduced supplements may have contained unclean water or pathogens introduced from their production. The authors did make the point that Marshallese genetic growth potential and hormonal functioning may be severely different from the American reference population used. Yet, they also made the point of stating that food and nutrition and socioeconomic status were probably a large factor as well, making for a synergistic effect. The high prevalence of malnutrition and anemia implied the reduction of their full potential for physical and mental growth/development (Alfred 1991).

In 1998, Joel Gittelsohn reported a pilot study titled “Applied Research Study to Reduce the Prevalence of Overnutrition and Undernutrition in the Republic of the Marshall Islands”.

Nutritional status and dietary composition were examined in a random selection of 180 Marshallese households including children and adults from five different locations in the RMI. This pilot study was formulated to provide sufficient information to generate ideas and hypotheses about the relationship between obesity, diet, and activity in the Marshall Islands. The key objectives were to assess the prevalence of overnutrition (obesity) and undernutrition (stunting, wasting) in adults and children and identify associated economic, dietary, activity and sociocultural factors. In the 1987 report by UNICEF, 25.1% of adult deaths were related to some condition for which obesity was a predisposing factor, including heart disease and diabetes. This report also determined that 27% of adult Marshallese over the age of 30 had type II diabetes and 50% of adults acquired type II diabetes by the time they were 50 years of age. The 1991 National Nutrition Survey, discussed above, also found a number of households where children were found to be undernourished and adults were overnourished. This study attempted to evaluate the intra-household patterning of this malnutrition phenomenon as well. Gittelsohn (1998) asked early in the study report about what age the transition from undernutrition to overnutrition occurred in an individual's life and what might be the sociocultural and environmental factors that appeared to predispose an individual toward current or later obesity.

The survey was conducted from July 1996 to December 1997. Five locations were selected for sampling and these included Delap, Uliga, Rita (categorized as one area) and Laura on Majuro Atoll, Arno Atoll, Ebon Atoll and Namdrik Atoll. These five locations were further grouped into urban and remote areas; the communities on Majuro Atoll represented urban areas where as Arno, Ebon and Namdrik Atolls were classified as remote. Rita, Uliga and Delap are often referred to as D-U-D. The Marshallese spelling of Rita is Djarret, therefore, D-U-D is an anagram representing these three communities and will be used when discussing results. The results of this research were reported noting these urban and rural distinctions as well. Each household visited had one member offer demographic information such as age, years of education, marital status, and reported diabetes status. Six anthropometric and body composition measurements were also taken on each household member. These included height, weight, triceps skinfolds, waist and hip circumferences, and percent body fat as determined through bioelectrical impedance. NHANES II reference data, compiled by Frisancho (1990), was used to assess body composition and nutritional indices of adults and some children. The research team also collected 24-hour dietary recalls, a household food frequency questionnaire, and an economic status questionnaire with each household and its present members. The economic status questionnaire had two main sections including an assessment of material style of life and questions regarding external sources of income and goods (Gittelsohn 1998).

The dietary recalls and food frequency questionnaires revealed information about food perceptions and consumptions. Participants made a clear distinction between *mona in ailin kein* (foods from our islands) and *mona in bele* (imported foods/American foods) in the urban area of Majuro. Foods from our islands included items such as breadfruit, pandanus, banana, papaya, taro, fish, pumpkin, drinking coconut, coconut crab, fermented breadfruit, coconut embryo, pig, clams, local chicken, arrowroot, sea turtle, sweet potato, lime, shellfish. Imported or American foods included rice, flour, orange, chicken, corned beef, apple, ramen, spam, egg, steak, cabbage, tuna, beef, cola, carrots, and bread. Urban areas categorized food into meats, vegetables and fruits, carbohydrates, beverages, and sweets. Healthy food items were usually equated with local or island foods and unhealthy items generally equated to imported foods. Canned meats and rice cookers were associated with modern urban lifestyle and “being lazy”. Yet, surprisingly, rice has replaced breadfruit as the staple carbohydrate in urban areas (Gittelsohn 1998).

Gittelsohn (1998) also stated that there was an obvious and significant correlation between degree of “urbanness” and the type of food consumed. More urbanized households were much less likely to eat island foods and much more likely to consume store bought foods. Of locally produced foods, the most commonly consumed across all sites were reef fish, banana, breadfruit, and coconut. Foods such as papaya, banana, breadfruit and coconut were 2-5 times more likely to be consumed in remote areas than in urban areas. Of imported foods, the most commonly consumed were white rice, tea/coffee, noodles and canned fish. Canned meat, noodles, milk and pop were 2-5 times more likely to be consumed in urban areas than in remote areas. The author (Gittelsohn 1998) concluded that remote-urban differences in food consumption were largely a matter of availability and price. In urban areas, households consumed store bought foods high in fat and low in fiber much more frequently than in remote atolls. Urban households were also much more likely to fry their foods in oil. The reverse pattern was seen in terms of locally produced (island) foods, with remote atolls much more frequently consuming local island foods generally lower in fat and higher in fiber than their urban counterparts (Gittelsohn 1998).

The results of the anthropometric data analysis among adults and children in this study were interesting. The prevalence of overweight and obesity was approximately 56.5% in adults aged 18-50 years. The prevalence of overweight was higher among females (61.6%) sampled than males (50.5%) and also higher in urban areas in contrast to remote atolls. Rates of obesity increased sharply in women at about age 20 and in men in their 40's. The anthropometric survey data for children indicated that the rates of undernutrition among young children in the critical "growth years" (0-4.99 years) was on average 7% categorized as wasted and 39.6% being categorized as stunted, depending upon the gender and location. Urban households (D-U-D, Laura) have higher rates of obesity in all age groups than do remote households (Arno, Ebon, Namdrik). In urban areas, lower economic status was associated with higher rates of obesity. Stunting did not appear to differ by locale, but did differ by economic status within locale. In urban areas and after age 5, wealthier households had a lower prevalence of stunting, which the investigators argue reflected better access to food. Before age 5 though, the opposite pattern was seen. These contraindicatory patterns were suggested to be the result of infant feeding differences among urban and remote locations. Of the households sampled, 39% revealed some kind of intra-household discordance in nutritional status. The more prominent of all possible discordance patterns (30%) was that of concurrent adult obesity and child undernutrition, especially in households with >1 adult and >1 child (Gittelsohn 1998).

Although these results are of great interest and discussion later in the dissertation study, I again will turn towards the pre-school and school-aged children examined in this study. Table 2.2 displays the distribution of the pre-school and school-aged children examined in Gittelsohn's study. Again, the urban sample included children from the communities of Rita, Uliga, Delap and Laura on Majuro Atoll. The rural sample included participants living on Arno, Ebon and Namdrik atolls. Table 2.3 displays the percentage of stunting found among these locations and age categories as Gittelsohn reported them. This display of the data also presented the categorization of the sample into three socioeconomic statuses. These socioeconomic statuses were determined from the information Gittelsohn collected from the economic status questionnaires distributed to each sampled household. These questionnaires were based on a range of scores from 1-30 with 30 representing the highest socioeconomic status a household can be ascribed. Low socioeconomic status represented a score of 1-10, medium socioeconomic status represented a score of 11-20, and high socioeconomic status represented a score of 21-30. In regards to the percentage of stunting, no apparent differences were seen between locale, but some marked differences were observed within locale by economic status. In the youngest age group (<5y), higher economic status was associated with a higher prevalence of stunting in the urban area.

Table 2.4 displays the percent of children wasted, defined by body mass index, by age, location and economic status. Generally, wasting appeared to be a bigger problem in urban than remote areas. Gittelsohn (1998) suggested that this may be possibly associated with higher rates of infection by communicable diseases. He also suggested that sanitation and infant feeding practices might be a factor. Tables 2.5, 2.6, and 2.7 present the percent of undernutrition, overnutrition and obesity among the age and sex groups in the sample. Gittelsohn did not present undernutrition and overnutrition in terms of socioeconomic status. Stunting and low weight-for-age were the most pronounced nutritional problems discovered. The prevalence of low height-for-age was significantly higher in general and was also similarly represented across age ranges. In contrast to those children demonstrating low height-for-age, only 5.8% and 7.0% demonstrated excessively low weight-for-height ratios. The prevalence of stunting and low weight-for-age appeared to increase among the 10-17.9 year olds in the sample. The increase was greatest among males (+20%) compared with that of females (+6%), though this was partly attributable to the higher prevalence of stunting among females in the previous age cohort. The prevalence of low weight-for-age among males also demonstrated a large increase (+10%) compared to that of females in the same age group (+2%). The reasons for increases in prevalence among this age group were unclear according to Gittelsohn. He questioned whether the Marshallese girls were reaching menarche or if Marshallese boys were possibly more active. The adult prevalence rates for stunting mirrored those of the youngest age groups. These findings may reflect some measure of catch-up growth during the teen years. Also, as with those younger groups, these findings might have been an artifact of the reference population used (Gittelsohn 1998).

There were few obese and overweight teenagers in the sample (with the exception of a small percentage (5.6%) of overweight teenage girls). Obesity rates were fairly similar between urban and remote areas, even though food differs from one setting to the next. Almost a third of all adult males and females were found to be overweight. Substantially more adult women than men were obese. Body mass index measures of household members showed that by age 20-24, a substantial proportion of both men and women were overweight. Overweight and obesity were more pronounced in women than in men. Among young and middle-aged adults, lower economic status appeared to be associated with increased rates of obesity in urban areas. This pattern was not seen in the remote areas sampled (Gittelsohn 1998).

Gittelsohn concluded his report by discussing limitations and applications of the pilot study. He first states that the study represented a range of different settings in the RMI, but it was not representative of the whole country. In particular, Ebeye was not represented where a third of the Marshallese population lives. The researchers recognized that only a portion of the population was represented and recommend future studies that would include larger subject pools from urban and rural atolls. Gittlesohn also recommended the study of nutritional content of each individual subject's diet. As mentioned, another finding from the Gittelsohn pilot study was that many households displayed adult overnutrition and child undernutrition. This point needs to be expanded upon in additional research. Furthermore, the prevalence of obesity and diabetes needs to be confirmed in a larger sample. Going further, the relationship between obesity and chronic disease needs to be explored at large in the Marshallese population. Malnutrition during pregnancy and early childhood may be linked to chronic disease in adults. Strong associations have been found between low birth weight and stunting, obesity, insulin resistance, diabetes and CV disease in adults (Gittelsohn 1998). Gittelsohn felt that although the pilot study provided sufficient information to generate ideas and hypotheses about the relationship between malnutrition, diet and activity, these mentioned limitations need to lead to further study in the Marshall Islands.

The final nutritional assessment is briefly reviewed here as it focuses on infants and children aged from birth to five years. Victoria Gammino, a student of Gittelsohn's, conducted a follow-up study to Gittelsohn's pilot study in 2001. This survey explored feeding practices and nutritional assessment for 150 children from both urban and rural areas similar to Gittelsohn's pilot study. Data on recent illnesses, breastfeeding and infant weaning patterns, 24-hour dietary intake, height, weight, mid-upper arm circumference, head circumference and triceps skin folds were collected for each infant and child in the study. She examined nutritional status by exploring weight-for-age, height-for-age, and weight-for-height z-scores utilizing the NHANES II reference data (Gammino 2001).

Gammino completed 137 infant feeding histories out of the 150 children included in her study. She found that 98.5% were breastfed as children and 35% of them also received formula at various points in time. The mean duration of breastfeeding was 10.7 months with no difference in duration of breastfeeding seen across sites. The mean duration of exclusive breastfeeding though was only 2.5 months. Only 16.4% of the children surveyed met the UNICEF recommendations for exclusive breastfeeding through six months. The duration of exclusive breastfeeding varied significantly by location ($p<0.001$) with rural children receiving exclusive breastfeeding longer than urban children (Gammino 2001). Among infants that were not exclusively breastfed through six months, the mean age of introduction of non-breastmilk liquids such as water or coconut milk was 4.9 months. Gammino's interview data found over 40 weaning foods with a majority of these items composed of common local ingredients. Urban areas relied on flour gravy and imported items whereas rural children of this cohort were introduced to weaning items such as fruit and vegetable purees created from locally grown food items (Gammino 2001).

The overall prevalence of stunting for infants and children in this study was 39.3%. There was no significant difference in prevalence by sex and study sites. One interesting observation was that as children increased in age, the prevalence of malnutrition increased (Gammino 2001). For infants under the age of 1, the prevalence of stunting was 21.4%. This prevalence then increased to 42.9% for infants aged 12 to 24 months. By the time children reached the age of five, the stunting prevalence increased to 63.2%. When Gammino (2001) stratified the sample by age and location, the mean height-for-age z-score among urban children (-2.54) was significantly lower than rural children (-1.63) ($p<0.01$). Gammino only found two cases of wasting and these were both male children. When exploring weight-for-age, 22.6% of the sample was considered moderately to severely underweight. The highest rates of low weight-for-age were observed in children under the age of 2 years (Gammino 2001).

One major pattern identified by the data was that a high clustering rate of poor nutritional status was identified in extended households and large nuclear families. The prevalence of stunting in households with more than one child less than six years was 51% versus 18% in households with only one child less than six years. The mean number of children did not differ in each type of household. Rather, the number of children under six appeared to be the important variable in this setting. The children with "no household competition" under six fared better and the allocation of parental resources, such as increased time for caregiving and food preparation might have been the cause here (Gammino 2001).

Taking breastfeeding, weaning and growth measures together, the association posited by "the weanling's dilemma" regarding the dietary transition from breast to early weaning foods may be a reality in the Marshall Islands. The mean height-for-age z-score was found to be lower in children of comparable age on a transitional, low breast milk diet compared to children on a diet with higher breast milk content. This finding was probably attributable to an increase in diarrheal morbidity from the loss of immunological protection afforded by breast milk, a decrease in the calories from breast milk not offset by nutritionally adequate weaning foods, or a combination of both (Gammino 2001).

My Dissertation

The previous work completed by Julia Alfred, Joel Gittelsohn, and Victoria Gammino is built upon in this research study. Gittelsohn's pilot study explored many facets of nutrition and health among Marshallese Islanders among all ages and various locations throughout the country. As Gittelsohn suggested, further targeted exploration needs to occur in these age groups and locations. Victoria Gammino's work in 2001 focused on children aged birth to 5 years of age in both rural and urban environments. My dissertation continues the trend that Gammino started and focuses on the next sequential age group, school aged children (5-14 years). Unlike Gammino and Gittelsohn though, my dissertation will focus on school aged children living on the capital atoll, Majuro. Gittelsohn suggests larger subject pools from targeted niches in the Marshallese population and so my study will focus on school-aged children living on the most urban atoll. The nutritional and anthropometric assessment completed here will offer an update for comparison to previous studies to evaluate the health of children living on Majuro as well as any attempts to intervene on these previously reported malnutrition rates and issues.

Chapter 2 Tables and Figures

Table 2.1: Malnutrition Rates from Previous Nutritional Assessments in the RMI

Source	Year	n	Age	Malnutrition Rate	
Majuro Hospital Internal Records	1987-1989		0-5 years	10.0%	**Underweight (moderate to severe)**
			6-14 years	35.0%	**Underweight**
				8.0%	**Overweight**
National Nutritional Survey	1991	629 (Total) 239 (Majuro)	0-6 years	20.0%	**Underweight (moderate to severe)**
				36.0%	**Underweight (mild)**
				36.0%	**Normal Weight**
				8.0%	**Overweight**
				24.0%	**Stunted**
				3.0%	**Wasted**
			7-14 years	40.0%	**Underweight (moderate to severe)**
				35.0%	**Stunted**
Gittelsohn	1998	129	0-5 years	39.6%	**Stunted**
				7.0%	**Wasted**
		467	7-17.9 years See Tables II-VII	40.0%	**Underweight (moderate to severe)**
				35.0%	**Stunted**
				2.0%	**Wasted**
Gammino	2001	150	0-5 years	22.6%	**Underweight (moderate to severe)**
				39.3%	**Stunted**
				1.3%	**Wasted**
Hughes et al.	2004	99 (Rita)	5-12 years	8.1%	**Underweight**
				25.3%	**Stunted**
		173 (Laura)	5-12 years	16.3%	**Underweight**
				32.5%	**Stunted**

Table 2.2: Sample Distribution (Gittelsohn 1998)

Age Group	Urban (D-U-D, Laura)		Remote (Arno, Ebon, Namdrik)	
	Male	Female	Male	Female
0-4.9	35	33	36	25
5-9.9	48	48	64	44
10-17.9	62	82	57	62
Total	145	163	157	131

Table 2.3: Stunting (%) by Age, Location and Economic Status (HA < -2SD) -- (Gittelsohn 1998)

Age Group	Urban (D-U-D, Laura)			Remote (Arno, Ebon, Namdrik)		
	Low	Med	High	Low	Med	High
0-4.9	16	42	50	40	29	38
5-9.9	46	31	19	43	40	17
10-17.9	51	44	33	52	52	42

Table 2.4: Wasting (%) by Age, Location and Economic Status (BMI < -1.65 SD) -- (Gittelsohn 1998)

Age Group	Urban (D-U-D, Laura)			Remote (Arno, Ebon, Namdrik)		
	Low	Med	High	Low	Med	High
0-4.9	5	6	6	0	0	9
5-9.9	0	10	0	5	0	2
10-17.9	6	6	9	3	0	2

Table 2.5: Undernutrition (%) by Age and Sex -- (Gittelsohn 1998)

Age Group	Stunting (Height/Age < -2SD)		Wasting (BMI < -1.65 SD)		Low Weight for Age (Weight/Age <-2SD)	
	Male	Female	Male	Female	Male	Female
0-4.9	32.1	39.6	5.8	7.0	21.4	33.3
5-9.9	28.8	35.2	1.8	0.0	13.4	12.0
10-17.9	48.7	41.7	0.0	0.0	24.4	14.0

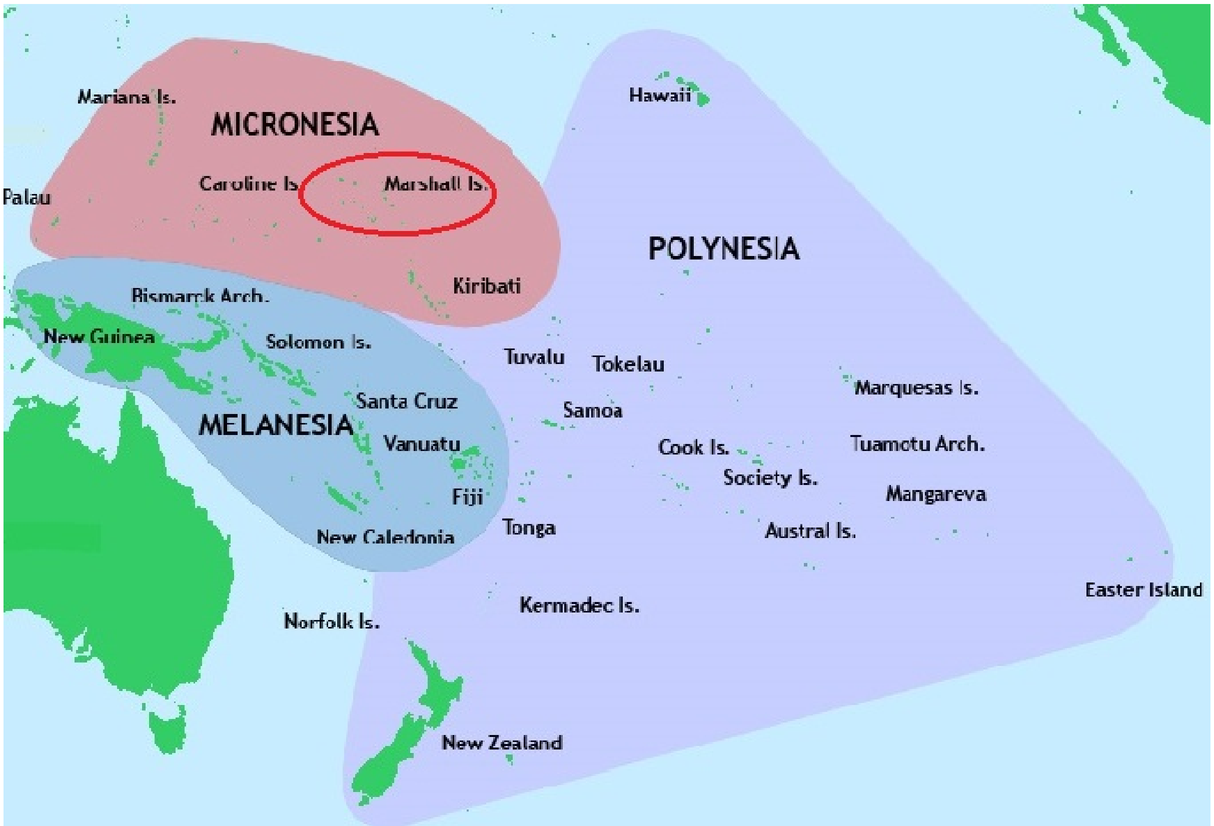
Table 2.6: Overnutrition (%) by Age and Sex -- (Gittelsohn 1998)

Age Group	Overweight (25-30)		Obese (>30)	
	Male	Female	Male	Female
0-4.9	1.4	0	1.4	1.7
5-9.9	0	0	0.9	1.1
10-17.9	0.8	5.6	0	1.4

Table 2.7: Obesity (%) by Age, Location and Economic Status -- (Gittelsohn 1998)

Age Group	Urban (DUD, Laura)			Remote (Arno, Ebon, Namdrik)		
	Low	Med	High	Low	Med	High
0-4.9	0	9	0	0	0	0
5-9.9	5	0	0	0	0	0
10-17.9	2	0	0	3	0	0

Figure 2.1: Island Nations of the Pacific Ocean

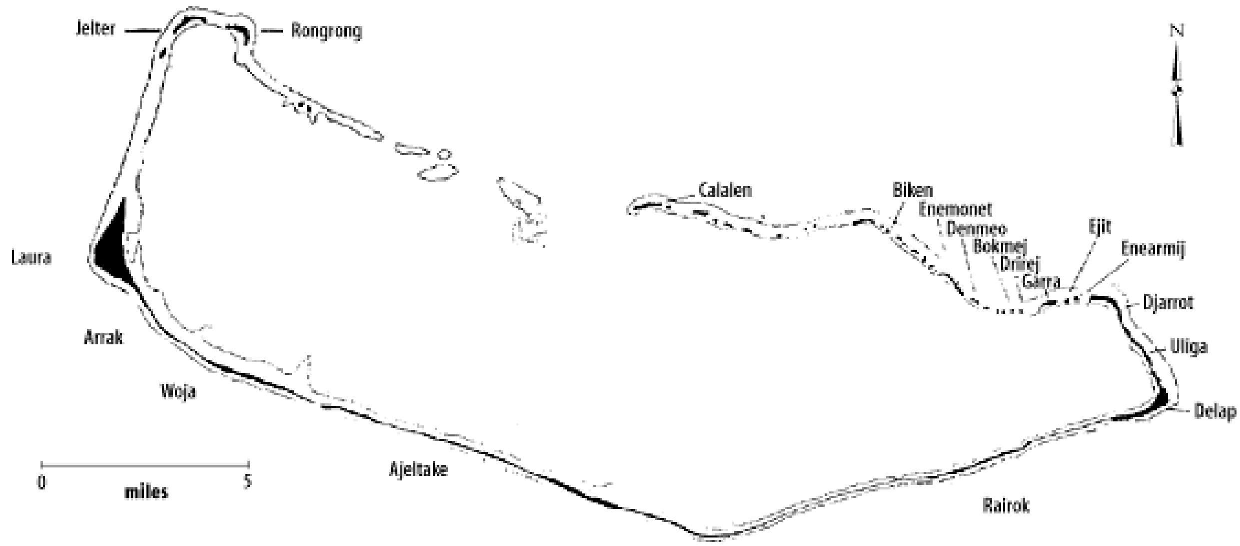


Map modified from Wikipedia.org, 2015

Figure 2.2: The Marshall Islands

Map modified from U.S. Department of State-Bureau of Consular Affairs, 2015

Figure 2.3: Majuro Atoll



Map modified from UNDP and EPPSO, 2004

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Chapter 3: Methodology

Overview

Initiating this study required the principal investigator to travel to the research site months in advance of data collection. Obtaining human subject study approvals from Indiana University and the Republic of the Marshall Islands Ministry of Health (RMI MOH) required face-to-face meetings with RMI government officials, Majuro primary school principals and staff, and parents. Project documents needed to be accurately translated into Marshallese, an Austronesian language, before they could be approved and implemented in the study. It was difficult to find someone in the United States who could translate the study material into Marshallese. Equally, it was difficult coordinating what should be included in the informed consent, child assent, and other study documents without these face-to-face meetings.

Once human subjects clearances were obtained from Indiana University and RMI MOH, subject recruitment began. This chapter outlines the procedures and protocol used to recruit study participants and measure and collect data. A discussion of planned versus obtained data, data characteristics and measurement error also follows.

Approvals

I arrived in Majuro on August 1, 2008 and began to distribute a Letter of Intent (Appendix A) to the Secretary of Education, the Secretary of Health, and the Secretary of Internal Affairs. I also conducted formal meetings with each of these Republic of the Marshall Islands (RMI) representatives to discuss the project and investigator needs as well as obtain permissions to move forward. The Secretary of Health signed a Letter of Support for the project and referred the investigator to the RMI Human Subjects Review Committee (RMI HSRC). A full-review presentation was scheduled with this committee and conditional approval was granted. Full approval could not be given until Indiana University's Internal Review Board (IRB) approved the study. But, IU's IRB would not give full approval until the RMI HSRC granted full approval. A personal account of this situation can be reviewed in the publication "Disasters in Field Research" (Ice, Dufour, Stevens 2015: p. 14). After considerable interaction and discussion between both IU's IRB and the RMI HSRC, IU's IRB granted full approval to the study on January 7, 2009 (Appendix B).

Subsequently, the RMI HSRC granted approval and I met with the Secretary of Education to get signed approval letters to distribute to each of the public school principals. All public schools are under the administration of the RMI Ministry of Education (MoE). MoE gave full support to this project and granted access to their public schools on Majuro. Private schools were contacted prior to and after IRB certification and their principals and board of directors gave verbal and written permission for access to their schools. There are eight public schools on Majuro including Rita, Laura, Woja, Ajeltake, Uliga, Rairok, Delap and Ejit elementary schools. There are also seven private schools located on Majuro. Figure 3.1 shows the approximate location of these schools on Majuro. Only three private schools agreed to participate in the study (Majuro Cooperative, SDA Delap Learning Center, and Assumption Catholic). A lot of speculation and caution was expressed from private school administrators and parents. A few of the private schools made statements regarding their nervousness about "stirring up problems in the government when showing any differences between public and private school kids."

As already discussed, I met with every one of the public and private school principals to discuss the project and distribute the Letter of Intent. Upon approval by the two governing human subjects bodies, IRB approval letters, signed Letters of Support from the Secretary of Education and Health and a Confirmation of Participation letter (Appendix C) were distributed to every public and private school principal on Majuro Atoll.

Participant Recruitment

Since the project examines the growth and development of children living and attending schools on Majuro, any child attending a participating private or public school, and in grades kindergarten through eighth, was considered a potential participant. The child's grade level was taken into consideration as opposed to sampling strictly from age, so there was an overlap in ages from grade to grade. One school in particular, Delap Elementary, had a separate class titled 'Special Education'. This class included children who started elementary school at a later age or who displayed learning difficulties. This class did not include any children with developmental problems as the title of the class might suggest to people familiar with Western education formats. A child in Majuro may start attending kindergarten at the age of four. Many children do not start school until eight, nine, or even ten years of age as suggested by the 'Special Education' class. Based upon 2005-2006 Majuro government surveys, the total enrollment for children aged four to seventeen was approximately 4, 829. This represents a little over 83% of the population in that age range living on Majuro (United Nations Development Program and Economic Policy 2004). In the 2005-2006 school year, a majority of these children attended public schools (72.2%) with only 27.8% attending private schools.

There were two methods of recruitment used in this study. First, a 13-slide Power Point presentation was scheduled during Parent-Teacher Association (PTA) meetings at both private and public schools. Parents and children were presented with the details of the project and the informed consent document was discussed. An outline of the PTA meeting presentation summary and guidelines can be found in Appendix D. Informed consent forms (Appendix E) were distributed to the parents at these meetings. Parent(s) or guardian(s) attending PTA meetings were instructed to follow three steps: 1) If they chose to have their child participate in the study, they could sign the documents, fill out their contact information, put it into an envelope provided, and drop it off in a box present at the meeting, 2) If they wanted additional information or a discussion of the project privately with myself or school principal, they could fill in their contact information, put the forms in the envelope, and drop it off in the box, or 3) If they chose to not have their child participate in the study, they could place the unsigned forms into the envelope, and drop it off in the box. All parents attending the PTA meeting were instructed to place their envelope in the box before leaving the meeting, regardless of whether they were participating or not. This procedure was completed in order to protect the parent/guardian and child's privacy in an open forum. Multiple private meetings were undertaken with parent(s) or guardian(s) to discuss participation in more detail.

The second recruitment method involved the distribution of informed consent documents by the school principals directly to the parent(s) or guardian(s). Parent(s) or guardian(s) who received informed consent and personal health information (PHI) documents from principals were given the opportunity to sign the informed consent statement at their leisure when they had made an educated and informed decision about their own and their child's participation in the project. I met with each school's principal to discuss the specifics of the project and review privacy procedures for parent(s) / guardian(s). The informed consent statement also provided parent(s) or guardian(s) with my email and phone number if they wished to discuss the project in more detail and ask questions.

Parents and children who agreed to participate in the study were contacted in a number of ways. First, parents were contacted by their choice of phone, email, or home visit in order for them to get additional information or complete questionnaires involving their children. Second, children were approached directly at their schools for data collection. Anthropometric measurements and 24-hour food recalls were conducted with participating children during the school day, except during lunch periods.

Procedures and Data Collection

Data were collected and recorded with a subject number assigned to the participant. There were two ways to identify the child with the collected information. The first involved the informed consent statement that included the child's name, the parent's name and the assigned subject number. The second way involved a master list of child names and their subject number. I only had access to these documents as they were kept in a locked and secure filing cabinet located in my residence on Majuro.

Once parents and children gave informed consent to participate in the study, a number of data collection methods were used. Children were approached at their school of attendance for anthropometric data collection. Children who had informed consent clearance were randomly brought to the nurse's station, principal's office, or other private location in the school for data collection at random moments during the school day. Therefore, children may have missed some class work or their recess period by being called to the data collection area. Children were not sampled during their lunch break. Coordination with school principals and teachers was completed in order to choose data collection days and times that would interfere as little as possible with the child's education and/or classroom activities.

The initial protocol included the use of a hired research assistant who would help record data measurements, translate unclear material to children, and assist the overall functioning of the project. One to two week training periods were organized for these research assistants before data collection occurred. Unfortunately, these hired research assistants became unreliable due to conflicts of time and insufficiencies related to travel. The protocol was adjusted to collect anthropometric data with the assistance of a representative from each school. Each child was read the child assent document (Appendix F) and introduced to the school appointed assistant before data collection began. The "research assistant" not only monitored data collection, but also was present to ensure the safety of the child. The child was required to sign the assent document before proceeding.

Verification of Birthdate

The informed consent statement notified the parent that I planned to view and record data from the child's Ministry of Health yellow card that is stored at the school and Majuro Hospital. The yellow cards are given out to all children in the Republic of the Marshall Islands and they accompany birth records. These cards contain the name, date of birth, place of birth, weight at birth, birth mother's name, father's name, immunization administration dates, Vitamin A administration dates and weight tracking data. A 'Request to View Personal Health Information Form' (PHI) accompanied every informed consent statement in order to collect information from these yellow cards. School principals would verify the child's birthday or inform myself of the correct date from each participating student's yellow card. Children were also directly asked to identify their birthday and age during the data collection period. According to Goodman (1999), some researchers are unable to obtain clear results in nutritional assessments when relying on children and adolescents to identify their age. This point is especially prevalent in the Republic of the Marshall Islands as the population does not place cultural economy or value in knowing one's age. Therefore, verification of birthdates was a priority in this study to ensure accurate results and assessment.

Anthropometrics

Anthropometric measurements included height (cm), sitting height (cm), weight (kg), elbow breadth (cm), mid-upper arm circumference (cm), triceps skinfold (mm), subscapular skinfold (mm), and suprailliac skinfold (mm) using the right side for bilateral measurements. These measurements were recorded a second time with thirty-three randomly chosen children. Repeated measurements allowed me to check intra-observer error in the measurements collected. The results of the error analysis are presented later in this chapter. The average time to collect anthropometric measurements with each child was about five minutes. The anthropometric data collected represents a cross-sectional examination of Majuro children. Although longitudinal data is preferred for growth analysis, cross-sectional data can still reveal important trends about size attained, timing, and rate of development in a population (Malina, Bouchard and Bar-Or 2004, Delgado et al. 1986, Waterlow et al. 1977). These measurements followed the specific techniques described by the Anthropometric Standardization Reference

Manual (Lohman, Roche, and Martorell 1988) and the technical instruction provided by Dr. Paul Jamison, Indiana University.

Stature, or height, was measured using a GPM manufactured anthropometer while the participant stood erect with their hands hanging freely at both sides and their weight evenly distributed on both feet. The heels of the feet were touching while the medial borders of their feet were positioned at a 60 degree angle. The participant was measured with bare feet and their head was placed in a Frankfort horizontal position. Before taking the measurement, the participant was asked to stand fully erect and to take a deep breath. The anthropometer was pulled down to touch the top of the participant's head while attempting to compress the hair to get the most precise reading. The measurement was recorded to the nearest 0.1 cm. Stature is important because it is a major indicator of achieved body size, bone length, and when compared to age, can inform the researcher about the chronic relationship of nutritional deficiencies (Lohman, Roche, and Martorell 1988, Shakir and Morley 1974).

Weight was measured using a Tanita BF-350 bioelectrical impedance scale with a leveled platform. As long as the participant could stand erect without the aid of another person, they were asked to stand directly onto the scale. The participant would still be required to remove their shoes and socks for this measurement. As long as other clothing worn was not heavy and bulky, they were not asked to remove any other clothing. I recorded the measurement to the nearest 100 g. Weight is an important measurement because it tells the researcher something about the mass of the participant. Weight can be important in the assessment of unusual growth, obesity, and acute undernutrition (Lohman, Roche, and Martorell 1988, Shakir and Morley 1974).

Elbow breadth was measured using a GPM manufactured broad-faced sliding caliper. The participant was asked to raise their right arm to a horizontal position and to flex their forearm to a 90 degree angle. I would face toward the participant while the back of their hand was directed towards the researcher. The medial and lateral epicondyles of the participant's humerus were palpated and the spreading caliper tips were placed there. Firm pressure was applied so that I could exclude the influence of the soft tissue while still making the measurement comfortable for the participant. This measurement was recorded to the nearest 0.1 cm. Elbow breadth can be used as an index of skeletal mass and a measure of frame size using calculations devised by Frisancho (1993) and McDowell et al. (2005).

Mid-Upper arm circumference (MUAC) was measured using a standard vinyl tape measure. The technique used here involved finding the midpoint of the right upper arm. The participant was asked to flex their forearm to a 90 degree angle with the palm of the hand facing superiorly. The lateral tip of the acromion process and the posterior portion of the olecranon process were palpated and marked with a red or blue dot sticker. The tape measure was then used to measure the distance between these areas and the midpoint was identified and marked with a sticker. The participant's arm was then relaxed, the elbow was extended with the arm hanging slightly away from the trunk of the body, and the palm was directed towards the participant's thigh. The tape was then wrapped around the upper arm at the marked midpoint. I made sure that the tape did not compress the soft tissue of the arm of the participant and the measurement was recorded to the nearest 0.1 cm. Mid-Upper arm circumference, when used as part of a calculated index, can provide a measurement of energy storage and protein mass present in the participant (Martorell et al. 1976). The measurement can also be used in conjunction with skinfold thickness from the same area of the arm in order to calculate arm-muscle circumference and the areas of arm muscle and adipose tissue (Shakir and Morley 1973). Mid-Upper arm circumferences were also used to directly compare averages with the reference population.

Three skinfold measurements were collected for this research project. Skinfolds were measured using a Lange skinfold caliper with a maximum measurement of 65 mm. The participant stood erect and faced forward while I stood behind them. The triceps skinfold measurement was taken at the same marked midpoint location as the Mid-Upper Arm Circumference. The midline of the posterior portion of the participant's arm was used for the measurement. The participant's arm was hanging loosely at their side once again. The skinfold was taken up with my left thumb and index finger just above the site of the measurement. I then guided the arm to a 90 degree position one or two times in order to ensure that no muscle was being included in the measurement. The skinfold caliper was then placed onto the measurement site and the average of two measurements was recorded.

The subscapular skinfold measurement required some additional methodology with females that deviates from Lohman, Roche, Martorell (1988) and Jamison (2008, personal communication). The shirts of the participants in the study were not removed due to the nature of measurement collection. It would be considered inappropriate for a male to touch or see the bare skin of female children and adolescents in the Marshall Islands. For female participants, their shirt was pulled away from the body and a double fold of the shirt was measured in order to determine the thickness of the shirt. This measurement was recorded to the nearest 0.1 cm. The inferior angle of the scapula on the participant was then palpated. At an infero-lateral angle from this landmark, a double fold of skin, including the participant's shirt, was taken up by my left thumb and index finger just above the site of measurement. The caliper jaws were then placed around this fold and the measurement was recorded to the nearest 0.1 cm. The final subscapular skinfold measurement was calculated by subtracting the thickness of the subject's shirt from the combined thickness of the subject's shirt and skinfold. It is understood that some error is introduced with this measurement method.

Suprailiac skinfolds were measured immediately above the iliac crest at the midaxillary line. The participant's right arm was slightly abducted to allow access to the site. An oblique skinfold was pinched posteriorly to the midaxillary line and an angle of 45 degrees. The measurement was recorded to the nearest 0.1 cm.

Triceps, subscapular, and suprailiac skinfolds are important in this study because they can be used to assess the fat patterning on the appendicular and axial skeleton. Subscapular skinfold is also an important measure of nutritional status and may be used as an indicator of total body fat (Martorell et al. 1976, Shakir and Morley 1973). These measurements have also been used to compare to the means of the reference population.

A major safety and privacy issue during the collection of anthropometric measurements with children involves the physical well-being of the young participant. Anthropometric measurements involve touching the child's body and asking them to stand, sit, or extend limbs in various positions. The perception of inappropriate touching is an ethical issue that is constantly discussed in anthropometric research (Haines et al. 2007, Moffat et al. 2005, Alderson 2000, Neumark-Sztainer 1999, Mayall 1994). Furthermore, a child's self-esteem and privacy may be violated if other teachers or students are present during the data collection.

Measurements such as weight can cause anxiety in a child concerned with issues surrounding body size, weight, and body image. These issues were constantly considered during data collection and none of these issues were expressed or occurred to the best knowledge of the investigator. If a child would have expressed discomfort, data collection would have ceased.

The distribution of the indices, such as height-for-age or weight-for-age, can be expressed in terms of z-scores, percentiles, and percent of median. Z-scores, also referred to as standard deviation (SD) units, are frequently used in comparative analyses. Z-scores indicate how many standard deviations a calculated variable, whether it represents an individual or group average, is away from the mean of a reference or standard data set. A Z-score can be thought of as the normal random variable of a standard normal distribution. A z-score can be calculated with the following formula: $z = (x - \mu) / \sigma$. If a study population has a mean height-for-age that is the same as the average height-for-age of the reference population; it has a z-score of 0. The z-score cutoff point recommended by WHO, CDC, and others to classify low anthropometric levels is 2 SD units below the reference median for the three indices (height-for-age, weight-for-age, and body mass index-for-age). The proportion of the population that falls above a z-score of -2 is generally compared with the reference population in which only 2.3% fall below this cutoff. Someone who is not familiar with z-scores should understand that z-scores increase both positively and negatively away from the mean. So, a z-score of -2.5 is higher than a -2 z-score. The cutoff for very low anthropometric levels is usually more than -3 SD units below the median (Tomkins 1994). Similarly, there are cutoff points of 2 and 3 SD units above the reference mean to indicate degrees of overweight and obesity, if exploring BMI, in the study population.

Percentiles, or "centiles," range from zero to 100, with the 50th percentile representing the median of the reference population. Cutoff points for low anthropometric results are generally <10th percentile, < 5th percentile or < 3rd percentile. In the reference population, 5% of the population falls below the 5th percentile; this can be compared with the proportion that falls below this cutoff point in the study population. Cutoff points for risk of overweight and obesity, based on BMI-for-age, are 85th to 95th percentiles and greater than the 95th percentile, respectively. In the reference population, 10% and 5% of the population fall above these cutoff points, respectively. The calculation of the percent of median does not take into account the often skewed distribution of the reference population around the median, especially for weight. Therefore, interpretation of the percent of median is not consistent across age and height levels or across the different anthropometric indices (Waterlow et al. 1986).

Traditionally, in the United States and some other countries, percentiles are more commonly used than in other parts of the world where z-scores or percent of median are preferred. The WHO favors the use of z-scores. Z-scores, based on normally distributed reference population data, are useful because they can be used to compare a research sample of individuals to the reference. In addition, z-scored data from male and female children and all ages can be combined to calculate the average z-score for the entire sample or compare average z-scores between all males versus all females. Percentiles are useful because they are easy to interpret (e.g., in the reference population 3% of the population falls below the 3rd percentile) (Mascie-Taylor 1994).

Questionnaires

A questionnaire was disseminated to the parent(s) or guardian(s) by mail or sent home with the child after each anthropometric measurement session. This questionnaire was accompanied with a Letter to the Parent or Guardian (Appendix G) as well. The survey asked twenty-nine questions regarding socioeconomic status, ethnicity (the defined category or group of people whom the parent identifies association with the child's ancestry), age of the parents, the recent health history of the child, family health practices, breastfeeding strategies with the child and other lifestyle factors. The survey was estimated to take ten to fifteen minutes for parents or guardians to complete. The questionnaire was content validated based upon Gittelsohn's pilot studies in 1998 and 2003. The construction of the questionnaire was guided by the recommendations by Bernard (2002). Yet, the questionnaire was not research validated and therefore some bias could have been introduced to the results of the study.

Once completed, parent(s) or guardian(s) were able to return the questionnaire in a stamped envelope addressed to myself. The information from this questionnaire was used in conjunction with information obtained from the child's Ministry of Health yellow card in order to explore social differences among Majuro children in chapter 6.

Participant Observation

I also kept a personal journal containing observations made about life on Majuro Atoll during the 17 month period I lived there. Comments, discussion notes, and other notable insights made by Marshallese children and adults were often recorded in the journal when I thought they were pertinent to the project goals and investigation. These observations are discussed in later chapters in order to support the findings of the study.

Data Management

Informed consents, child assent forms, anthropometric measurements, questionnaire responses, and yellow card data were all initially recorded on separate paper copies. As stated earlier, informed consents and child assent forms were kept in a locked filing cabinet located in my residence on Majuro. Each of these forms had a unique study identification number assigned to it. A master electronic copy of the participants and their unique study identification numbers was created and stored on my personal laptop computer. This computer was password protected and installed with encryption software provided by Indiana University. Separate paper copies of anthropometric measurements, questionnaire response, and yellow card data only contained the participant's unique study identification number. These forms were stored in a separate locked filing box away from the informed consents and child assent forms. The data from these forms were transferred into a data storage software program located on my personal laptop.

Limitations

There were two major limitations that occurred during the study. First, the study originally planned to conduct 24-hour dietary recalls with every participating child. The methodological design of these recalls was guided by Buzzard (1998). Fifteen of these interviews were conducted during the initial kick-off of the study. These interviews were taking about an additional ten to fifteen minutes to conduct. This approximate amount of time is in addition to the average time of 5 minutes needed to collect anthropometric measurements. Keeping a child out of class or recess for more than fifteen to twenty minutes was causing a problem with my and the child's productivity. The interviews conducted also revealed a problematic discovery. Many of these interviews were deemed useless because the responses from many of the children conflicted against what I knew about the child's diet from that day. For example, I was invited to eat lunch at many of the schools during data collection. The interviewed children often reported consuming different meals from what was made available to them at lunch. Because the validity of the information initially gathered was questionable and the time required to conduct these interviews was disruptive to the child's learning environment, these 24-hour dietary recalls were abandoned.

The second limitation is the involvement of schools, both public and private, in the study. One public school was not sampled because two of the scheduled PTA meetings for presentation were cancelled by the principal. The principal wanted the presentation to occur at these PTA meetings before any informed consent was distributed to parents. A discussion involving the participation of private schools has already occurred above, but it will be expanded upon now. SDA Delap, one of the private schools, made a mistake in the dates of open data collection. I did not get to present the study to this school's PTA until two weeks before I was scheduled to leave the country. Informed consents were also not distributed to parents in a timely manner. Although some students were eventually sampled from this school, it is largely under-sampled. Upon returning to the United States, I continued to receive signed informed consents from parents at this school. Over 250 informed consents were received after leaving Majuro.

Measurement error: Validity and Reliability

In order to validate the reliability of the anthropometric measurements, 33 randomly selected children were asked to go through the data collection process twice. Before collecting any data, potential sampling packets containing the paper forms for data collection were assigned participant identification numbers. These numbers were entered into SPSS 14.0 (IBM Corp. 2006) and 40 random identification numbers were selected using a random number generator. These sampling packets contained a specialized form for collecting anthropometric measurements twice. Although there were 40 of these specialized packets, only 33 of them were selected during the data capturing process for the consideration of measurement error.

Measurement error was assessed by calculating the Technical Error of Measurement (TEM) and the Coefficient of Relative Variation (CRV). The technical error of measurement (TEM) is defined as the squared root of the sum of the squared differences of replicates divided by twice the number of pairs (Figure 3.2). This value gives the researcher the ability to assess whether the degree of reliability of the given measurement is larger or smaller than that of other researchers (Jamison and Ward 1993, Frisancho 1990, Lohman, Roche and Martorell 1988). It acts as a potential range of error that could occur with each measurement explored. The coefficient of relative variation (CRV) is the TEM expressed as a percentage of the average size of the measurement. It allows the degree of error to be compared across a set of measurements (Figure 3.2).

Table 3.1 presents the investigator's calculated TEM and CRV for a majority of anthropometric measurements completed in this study. Weight is not considered here as an electronic BEI scale was used and calibrated with daily use. Table 3.1 also presents the published TEMs and CRVs from other researchers. Comparing my TEMs and CRVs for length and breadth measurements to other researchers allows me to conclude that the error present is similar or less than what they report. The TEMs and CRVs for skinfold measurements are similar or larger than those reported by the selected researchers.

Sample

A quick description of the collected data is presented here. Discussions of data analysis occur in the following chapters, but a quick discussion of the sample should occur here as it applies to the methodology. Table 3.2 presents the total number of Majuro children sampled in the study. These children are categorized by age and sex and a total of 588 children were measured anthropometrically. Ten of these children did not have a yellow card on file with the school principal and their actual age could not be confirmed. Children falling within the 4, 15, and 16 year of age category are removed from any analysis occurring in later chapters since the sample size in these categories is too small to be used for valid statistical analysis. A more in depth conversation on the justification for their removal occurs in the next chapter.

Table 3.3 displays the distribution of children by grade level and by sex in the sample used for analysis. 'Special Education' represents the children attending Delap Elementary in their Special Education class. Unfortunately, I was not able to obtain the class enrollment census for Majuro primary schools during the study period. But, I was able to obtain the class enrollment for Majuro private and public schools from school year 2005-2006 while in the field. This 2005-2006 census has been broken down to the grade levels sampled in Table 3.3. The percent of grade level sampled is also presented in Table 3.3. Only the schools sampled in my study were included in these enrollment figures. The next chapter beings the discussion of the nutritional and anthropometric assessment as it applies to all children sampled in the study. I explore any potential differences between public and private school children in the following chapter.

Chapter 3 Tables and Figures

Table 3.1: Comparison of Measurement Error among Selected Anthropometrists

	Stature	Sitting Height	Elbow Breadth	MUAC	Triceps Skinfold	Subscapular Skinfold	Suprailliac Skinfold
Foster TEM[1]	0.21	0.26	0.03	0.2	0.54	0.58	0.88
Foster CRV[2]	0.16%	0.37%	0.62%	1.04%	4.67%	5.29%	7.35%
Frisancho 1990 TEM[1]	0.692	0.535	0.117	0.347	0.8	1.83	
Lohman Roche Martorell 1988 TEM[1]		0.5 (12-17yrs.) 0.4 (school-aged)	0.1 (Buschang 1980)	1.54 (Hall et. al 1980) 0.24 (Martorell et al. 1975) 0.1 to 0.4 (Various)	0.4 to 0.8 (Various)	0.88 to 1.16 (Lohman 1981, Wilmore and Behnke 1969)	1.53 (Johnston et al 1974)
Tisone 2004 CRV[2]	0.21%		1.39%	1.20%	3.90%		

[1]Technical Error of Measurement (TEM)
[2]Coefficient of Relative Variation (CRV)

Table 3.2: Dispersion of Ages among Participants: Whole Sample

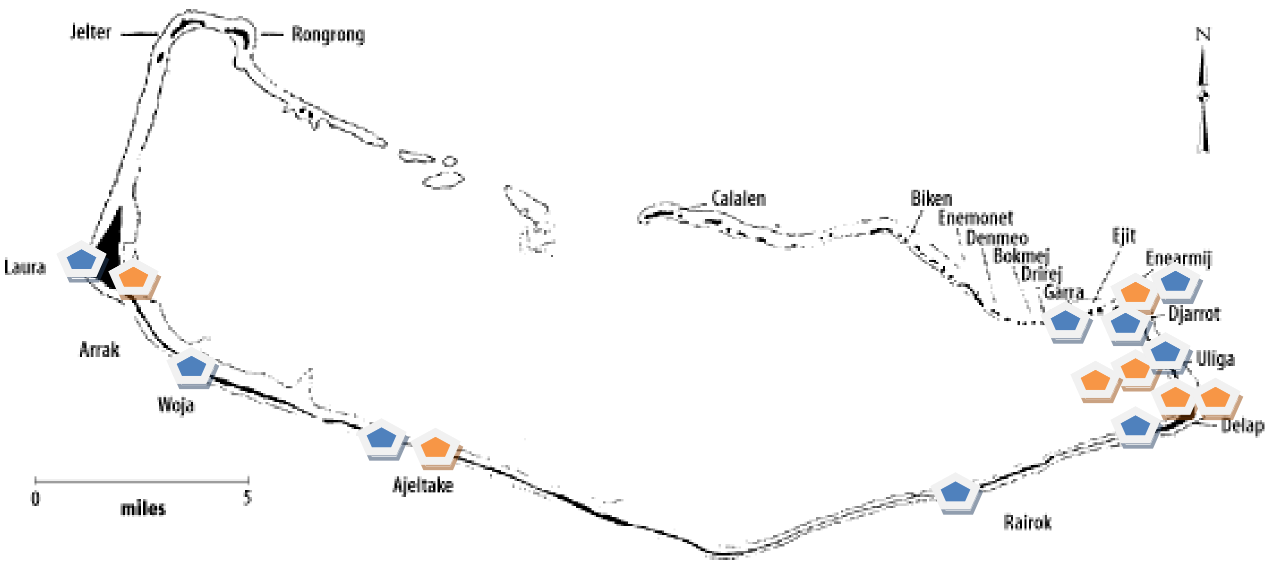
Age	n	Male	Female
4	2	2	0
5	13	7	6
6	37	22	15
7	59	32	27
8	83	44	39
9	75	37	38
10	80	40	40
11	79	45	34
12	75	40	35
13	45	25	20
14	24	16	8
15	4	2	2
16	2	2	0
Unknown	10	5	5
Total	588	319	269

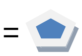
Table 3.3: Distribution of the Sample by Grade and Sex

	n	% of 2008-2009 Sample	2005-2006 Enrollment^	% of 2005-2006 Enrollment^
Grade Level				
K	16	2.8	313	5.1
1	57	10	563	10.1
2	73	12.8	544	13.4
3	93	16.3	473	19.7
4	98	17.2	460	21.3
5	76	13.3	451	16.6
6	65	11.4	409	15.9
7	48	8.4	418	11.5
8	26	4.6	360	7.2
Special Education	17	3		
Sex				
Male	308	54	2024	15.2
Female	262	46	1967	13.3

^These numbers include only the schools sampled in this study.

Figure 3.1: Public and Private Schools Located on Majuro Atoll



Key: Private School =  Public School = 

Map modified from UNDP and EPPSO, 2004

Figure 3.2: Formulas for Calculating Technical Error of Measurement (TEM) and Coefficient Relative Variation (CRV)

$$\mathbf{TEM} = \sqrt{\frac{\sum_{i=1}^{n}(\text{Day } 2_i - \text{Day } 1_i)^2}{2n}}$$

$$\mathbf{CRV} = \frac{TEM}{mean} \times 100$$

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Chapter 4: Nutritional Assessment of Marshallese Children

This chapter begins the exploration of nutritional and anthropometric assessments of Marshallese children sampled in this dissertation. Again, the sample includes children attending primary schools on the capital atoll of the Republic of the Marshall Islands, Majuro. A primary school included grades kindergarten through 8th grade. This sampling scheme did not necessarily follow perfect distribution of age and so I will discuss the modification of the 2008-2009 sample for the nutritional assessment of the entire sample before discussing the results. Once the stage is set for the sample here, I explore anthropometric measurements based on the World Health Organization 2007 Growth Reference Data. I then discuss body composition in the sample using A. Roberto Frisancho's (1990) Anthropometric Standards for the Assessment of Growth and Nutritional Status. Finally, I examine how these results relate to previous growth studies completed in the Republic of the Marshall Islands as well as briefly extrapolate from these results to historical comparisons with other Pacific Island nations. All analysis discussed in this chapter was completed using IBM SPSS Statistics 22 (IBM Corp. 2014).

Body Composition

Although the WHO 2007 reference is appropriate for international populations, such as the Marshallese sample, it does not allow for calculation of various body composition measurements considered important to exploring the nutritional status of a population. Specifically, the WHO 2007 and the CDC 2000 reference do not offer reference data for sitting height, elbow breadth, or upper arm muscle and fat areas. These measurements allow for assessment of skeletal structure and fat and muscle composition found among individuals or a population. For this reason, A. Roberto Frisancho's (1990) Anthropometric Standards for the

Assessment of Growth and Nutritional Status was used as the reference for Marshallese children. The reference is based on a sample of 43,774 subjects aged from 1 to 74 years. This subject pool was compiled from samples of the first and second National Health Examination Surveys completed during 1971-1974 and 1976-80 (Frisancho 1990). Since the Frisancho (1990) reference was collected from these time periods, it should be absent of the current upward trends seen with overweight and obesity among American populations. This was one of the rationales for the creation of the WHO 2007 reference. Although it would be ideal to use an Asian or Pacific Island population as a reference, no such population-specific body composition data exists. Despite the justification for its use, Frisancho's (1990) reference still leads to insufficiencies in the data analysis, particularly when examining upper arm muscle area by height. This issue is explained in more detail later in the discussion of the results.

Difference between actual and stated age

Noting anecdotal evidence from another anthropologist and her published material (Berman 2012), it was understood that inaccurate information is often collected from Marshallese children during interviews. Whether or not this reported information from children is considered "lying" in the traditional American definition is open for interpretation and no judgment can be made in this respect with this analysis. But, I asked participants to state their current age at measurement. Their actual age was recorded from birth certificates located in each of the school principal's offices. Only one child in the entire sample (n=588) admitted that they were unable to recall their age. Ten children (1.7%) in the sample did not have a birth certificate on file with the principal's office. Each child's age was treated as a ranked variable and a Wilcoxon signed-rank test was used to compare children's actual age with their stated age. A significant difference ($Z=-5.951$, $p<0.001$) was found when comparing stated and actual age. Therefore, as the evidence shows here, age should be confirmed by documentation and one should not rely on self-reported data as previous Marshallese nutritional assessments did.

When treating the age categories as continuous data, the mean stated age was 9.93 years and the actual age was 9.74. There seemed to be a trend where children overestimate their age. Any children with missing data in both categories were removed in this age comparison. One explanation for this overestimation may be due to the East Asian practice of increasing one's age when the new year begins as opposed to when one's actual birthday occurs. Overall, only 66.7% of the children sampled were able to accurately state their correct age at the time of participation in the nutritional assessment.

The sample includes 588 children from elementary schools on the Majuro atoll. Unfortunately, ten of these children did not have birth certificates on file with their school and their actual age could not be calculated. Because the results of age verification did not reveal an accurate rate of stated age, these children were not included here in the anthropometric and nutritional assessment. Obviously, accurate age estimation is of the utmost importance to the analysis when comparing an individual to a reference sample. If the wrong age of the child is used in comparison to either of the references used in this dissertation, the nutritional assessment results could lead to incorrect analysis and assumptions.

The Marshallese Sample and Anthropometrics

After the removal of the ten participants without a confirmed age and birth date, the sample consisted of 578 Marshallese children. A further reduction of the data was necessary before data was analyzed. Some of the sampled children in kindergarten classes were 4 years old. This same sampling issue also occurred with eighth grade where some of the children were 15 and 16 years old. The small sample size of ages 4, 15, and 16 led to their removal as participants in the study. I felt it was inappropriate to report on these age groups since each had less than three participants. The final sample used for analysis consisted of 308 males and 262 females ranging from 5 to 14 years of age.

A detailed explanation of the measurement types and techniques was discussed in the previous chapter. In brief review though, the following measurements were collected for each child in the sample: stature (cm), sitting height (cm), weight (kg), body mass index (kg/m^2), elbow breadth (cm), mid-upper arm circumference (cm), triceps skinfold (mm), subscapular skinfold (mm), and suprailiac skinfold (mm). The mean and standard deviation for each of these measurements are presented in Tables 4.1 and 4.2. For the sake of future researchers in the Republic of the Marshall Islands, any data not normally distributed has been highlighted in yellow. Many statistical tools require or assume that data is normally distributed and this notation has been made for their convenience. All data were tested for normal distributions using a Kolmogorov-Smirnov and/or Shapiro-Wilk test.

Issues Experienced with Calculation of Body Fat Percentage

Body fat percentage was another measurement collected from the sample. Table 4.3 presents this data for both males and females. One thing to note here is that the sample size for each age/sex category was not the same as the other measurements presented. A body fat percentage could not be calculated for two males and six females in the analyzed sample at the time of data collection, because; specifically, the Tanita 350 bioelectric impedance scale could not properly capture measurements on these individuals. There are a couple of possible reasons as to why it could not properly conduct an electrical impulse with these children. One reason involves the hydration of these children at the time of measurement. As noted in the methodology section, children completed anthropometric measurements at various times of the school day as allowed by the school curriculum and breaks. Some children were measured early in the morning and others were measured toward the end of the day. Children measured at the end of the day would have had opportunities for recess, exercise, and meals. Therefore, if a child was dehydrated, whether acutely or chronically, this could have had an effect on the measurement reading completed by the Tanita scale. Dehydration is a recognized factor affecting BIA measurements as it causes an increase in the body's electrical resistance and can cause an overestimation of body fat (Lukaski et al. 1986). Moderate exercise before BIA measurements can also lead to an underestimation of body fat percentage due to reduced impedance (Kuchner et al. 1996). Body fat measurements have also been noted to be lower when measurements are taken shortly after consumption of a meal (Slinde and Rossander-Hulthen 2001). This point should be considered by anyone referencing this Marshallese sample as the average readings presented here could be somewhat biased. A second possible reason is more of an anecdotal observation of the Marshallese population. Many Marshallese children, and adults to a lesser extent, walk, run and play without shoes. If footwear is worn, it is a simple sandal and these are reserved for school and church. By traveling barefoot around the coral island, thick, calloused feet are the norm among many Marshallese. This thicker pad of skin found on Marshallese feet could have caused problems for the Tanita 350 BEI scale as the electrical impulses sent through the body to measure fat resistance met even further resistance. For these reasons, the body fat percentage data is presented separately from the anthropometric measurement data.

There is a reference range for children's body fat percentage based upon a sample of American children (Jeb et al. 2004). The authors were able to construct these ranges based upon multiple methods for body fat percentage estimation and nutritional assessment. A graphic representation of these ranges is presented in Figure 4.1. Marshallese children's means for body fat percentage are presented as red diamonds for each sex/age category. These reference ranges do not include children aged 5 or 6 but they are still be considered here. For Marshallese females aged 5 to 11, they are considered "underfat". At age 12, Marshallese females in the sample reached the lower level of "healthy" body fat percentage. This increase in body fat may describe the onset of menarche. As for Marshallese males in the sample, the inverse direction of this pattern was seen. From age 5 to 12, the boys were considered to have a "healthy" body fat percentage. At age 13, the sample of boys crossed over into the "underfat" categorization.

Nutritional Assessment: WHO 2007 Growth Reference Data

Height-for-age

Stunting is the slowing of skeletal growth in children and it can reflect the poor overall economic conditions, particularly chronic or repeated infections and inadequate food intake (Monteiro 1991). There are various ways to estimate the prevalence of stunting in children while taking age, sex, and genetic growth potential of the child into account (Mora 1989, Monteiro 1985, Habicht et al. 1982). Monteiro reminds researchers that "in practice, it is impossible to determine the exact or expected height of any single child (Monteiro 1985: 165)''

Although reference populations allow for a comparison, often the assumption is that the sample population is a random selection from the reference population. This is not the case when applying the WHO 2007 reference to my Marshallese sample though. Going forward, Monteiro continues to state that "there is no single exact cut-off that is appropriate for determining the prevalence of growth deficits in all populations. Although cut-offs can be determined or set for any reference population, the observance of type-1 and type-2 errors can be introduced and overestimating or underestimating stunting can occur (Monteiro 1991: 761)."

The classical approach to classifying stunting requires calculating the proportion of children whose heights are more than -2 standard deviations (SD) of the mean value for the anthropometric standard or reference. One should recognize that z-score distributions do not follow a typical number line. Z-scores or standard deviations increase, both positively and negatively, away from the mean. A criticism of this approach is that the strict cut-off suggests "a strong imbalance between type-1 and type-2 errors, favoring the former, which is only appropriate when modest rates of growth deficit are expected (Mora 1989: 134).'' It is probable, as with most populations surveyed, that stunting may be significantly underestimated. Mora (1989) suggests standardizing the prevalence of stunting by accounting for the false positives and negatives from an observed population. Mora's (1989) approach also has difficulties because of how false positives and negatives are taken into account though. Verification of false positives and negatives requires a post-hoc examination of the measured children and I was not able to perform this task in the field. Therefore, the commonly accepted approach by the WHO is to utilize the classical method (more than -2 SD, e.g., -2.5 SD) in defining stunting and I will use this method in defining stunting with the 2008-2009 sample. It should be recognized that a level of underestimation has possibly occurred with the analysis though.

Tables 4.4 and 4.5 list the height-for-age z-scores for each age group among males and females respectively. Each table also categorizes these children as to which z-score level they belong. For example, a child with a -1.65 height-for-age z-score will be listed in the category -1. This category represents all children falling within -1.00 to -1.99 z-scores. The 0 category collects all children falling within -0.99 to 0.99 z-scores. This categorization technique has been completed for weight-for-age and BMI-for-age as well.

Starting with the Marshallese boys (table 4.4), a common trend was seen in regards to stunting. Thus, all age groups had mean height-for-age z-score values that were significantly less than the reference mean values. Except for the 13 year old age group, the boys' average height-for-age ranged between -1.39 and -1.79 z-scores. (It is probable that the Marshallese 13 year old age group's average z-score drops compared to the reference because the reference is reflecting puberty among American boys at this age. This assertion assumes that the Marshallese boys were hitting puberty at a later age not sampled here.) A one sample t-test was conducted for each age group using a criterion of "0"as the test value. With z-scores, zero would represent the mean of the reference population in this type of statistical comparison. The prevalence of stunting in the male Marshallese sample was 312% (96 males had z-scores greater than -2 SD out of 308 sampled).

For Marshallese girls, the only age group considered stunted by their average z-score was the 14 year olds. Caution should be exercised with this result, though, considering only eight 14 year olds were sampled. The Marshallese girls were statistically significantly lower in average height at every age category when compared to the WHO 2007 reference, although these children may not be defined as stunted (because their average height-for-age z-scores were less than -2 standard deviations of the mean reference population). The prevalence of stunting in the female Marshallese sample was 38.7% (101 females had z-scores greater than -2 SD out of 261 sampled). This prevalence was higher than the rate found with the sampled Marshallese males. When the male and female samples were combined, an overall stunting rate of 34.6% was calculated for the Marshallese sample.

Figures 4.2 and 4.3 display the cross-sectional data for my Marshallese sample against the WHO 2007 reference growth charts for males and females, respectively. A red dot for each age category represents the average height-for-age measurement displayed in Tables 4.1 and 4.2. A red diamond surrounding the average height for each category represents a significant difference from the WHO 2007 reference mean. Another addition to these growth chart comparisons is the red line connecting the age groups. Marshallese age groups having 20 or more participants are connected by a line. This action was taken to acknowledge the statistical strength of the sample size in each age category.

Figure 4.2 illustrates that the Marshallese boys were on a height trajectory falling slightly above the 3rd percentile of the 2007 WHO reference curve. Because the growth trajectory was fairly consistent, a question arose. Were Marshallese boys all experiencing chronic malnutrition or was there a populational difference in growth potential among Marshallese resulting in an average height lower than American populations? Figure 4.3 displays the same trajectory for

Marshallese females and this similar trajectory along the 3rd percentile of the reference reinforces this proposed question.

Weight-for-age

As stated previously, the 2007 WHO Growth Reference weight-for-age values only extend to 10 years of age. The reasoning behind this formulation involved the idea that weight-for-age is inadequate for monitoring growth beyond childhood due to its inability to distinguish between relative height and body mass. Stunting, thinness or underweight, overweight, and obesity in school-aged children should be assessed with height-for-age and BMI-for-age according to the WHO (de Onis et al. 2007). These references were created as a convenience for nations who still use weight-for-age to assess pre-adolescent children. Therefore, only Marshallese children aged 5 to 9 years were compared to the 2007 WHO Growth Reference.

Tables 4.6 and 4.7 display the weight-for-age average z-scores for each Marshallese age category for males and females, respectively. The z-score categorization is displayed again here for both males and females, but I will not make any assessment of the prevalence of low weight-for-age here as outlined by the 2007 WHO Growth Reference. The Marshallese males were statistically significantly lower in weight-for-age across all age groups. This trend was similar in Marshallese females as well. Although the mean z-score for 5 year old girls was not statistically significantly different from the reference mean, the sample size may have contributed to the result. The average weight-for-age measurements for both males and females are plotted on the WHO 2007 reference weight-for-age charts (Figures 4.4 and 4.5). As with height-for-age, the boys and girls both fell along a common trajectory of weight-for-age. When compared to the WHO 2007 reference, both males and females had a trajectory slightly above the 15th percentile at every age category. Therefore, the Marshallese children appeared to be more stunted than underweight when compared to the reference data.

BMI-for-age

The WHO has set BMI classification cut-off points for children based upon the work of de Onis and Lobstein (2010). Their cut-off points are: > -3 SD represents Severe Thinness or Underweight, > -2 SD represents Thinness or Underweight, > +1 SD represents Overweight, and > +2 SD represents Obesity.

Tables 4.8 and 4.9 present the average z-scores for body mass index compared to the WHO 2007 reference for males and females, respectively. The z-score categorization has been displayed here again as they were for height-for-age and weight-for-age. Color coordination of the BMI classifications has been added for the convenience of the reader. Table 4.8 shows that only one Marshallese male age group (Age 13) was statistically significantly lower than the reference. The rest of the male age groups fluctuated above and below the reference mean and were not statistically different from it. Following the outlined BMI cut-off points, none of the Marshallese males were considered to be experiencing Severe Thinness or Underweight. Going further, only three males were considered to be Thin or Underweight with a prevalence rate of 0.9%. Surprisingly, the prevalence of Overweight and Obesity was more common compared to Severe Thinness and Thinness among the Marshallese males with rates of 11.0% and 3.3%, respectively.

In comparison, none of the Marshallese female age groups were statistically significantly different from the reference, with average z-scores for BMI-for-age fluctuating around the reference mean. There were no individuals classified into Severe Thinness and Thinness categories among the female Marshallese sample. The rate of Overweight among the females was 7.7% and the rate of Obesity was 1.9%. These rates of Overweight and Obesity were slightly less among the Marshallese females compared to the males.

Figures 4.6 and 4.7 display the BMI-for-age cross-sectional data for our Marshallese sample against the WHO 2007 reference growth charts for boys and girls, respectively. Despite the findings for the height-for-age and weight-for-age comparisons, the trajectories for BMI-for-age, for both males and females, fell right along or slightly above the 50th percentile for the WHO 2007 reference growth charts. Following the growth chart logic here, the average BMI for Marshallese males and females should be considered to fall within the Normal range when compared to the WHO 2007 reference. Caution should be exercised with the interpretation here as body mass index is a proportional measurement. This issue is revisited later in this dissertation. The earlier question of whether the Marshallese sample was experiencing chronic and acute malnutrition or the exhibition of genetic growth potentials cannot be answered with this BMI-for-age data, but only strengthens our need to consider it going forward.

The International Obesity Task Force (IOTF) has created categorical cut-offs based upon BMI calculation and their reference data can also be used in the present assessment (Cole et al. 2007, Cole et al. 2000). These cut-off points are presented in Table 4.10 along with their subsequent classification. As one will note, there are unofficial cut-off points for Asian populations as there is common agreement among many researchers that cut-off points are population specific. Although this point has been discussed with respect to the appropriateness of reference populations used for nutritional assessment of a specific research population, some caution needs to be taken here when using these cut-off points to describe my

Marshallese sample. For instance, it might be more appropriate to use Asian cut-off points with Marshall Islanders. Marshall Islanders probably have more similar genes that influence growth patterns with Asian populations than they do to European or African populations. This assumption is made from the work bioanthropologists have completed in population genetics and how people migrated into the Pacific (Matisoo-Smith 2015, Duggan et al 2014, Corser et al 2012, Kayser 2010). Yet, this assumption discounts any specific Marshallese genetic growth patterns while also lumping every Asian population into one group. Another critique of the IOTF cut-off points is that there are no distinguishing cutoffs between the sexes, but there are cut-offs developed for children and adolescents (Cole et al. 2007, Cole et al. 2000). In expressing these concerns, for the purpose of analysis here, the average BMI measurements presented in Table 4.1 and 4.2 are explored. The average BMI for the Marshallese males was categorized as Thinness Grade 3 and Grade 2 from 5 to 10 years of age. At age 11, the Marshallese male average fluctuated between Thinness Grade I and Normal body mass index. The Marshallese female average BMI was similarly labeled as Thinness Grade 3 and 2 from age 5 to 10 years. Eleven year old females were classified as Thinness Grade 1 and 12-14 year old Marshallese females were considered to have a Normal body mass index. Thus, this classification might reflect a more specific categorization than the WHO categorization and results in, perhaps, a more realistic picture of the BMI values of the Marshallese sample. A caveat with my interpretation here is that many the average BMI measurement values were not normally distributed and the result may be biased. The use of z-scores for interpretation is strengthened here as z-scores standardize the results against the WHO 2007 reference.

Nutritional Assessment: Frisancho's Anthropometric Standards for the Assessment of Growth and Nutritional Status

As stated earlier, the WHO 2007 reference does not have body composition measurements for comparison. This reference data is also absent from the updated CDC 2000 reference. There are also no other appropriate body composition references from Micronesian or Pacific Island populations. Eveleth and Tanner (1990) reported on cross sectional growth studies from Australia, Melanesia, and Polynesian populations ranging from 1975 to 1985. A few of these studies included circumference and skinfold thickness measurements, but their sample size is not appropriate to be used as a reference. I compare average growth measurements between my Marshallese sample and these other Pacific Island populations, but I rely on A. Roberto Frisancho's Anthropometric Standards for the Assessment of Growth and Nutritional Status (1990) for body composition assessment. Although this reference has not been updated using the Box-Cox method for the creation of growth curves, it does include similar reference data used in the WHO 2007 reference. As stated earlier, Frisancho's reference leads to inaccuracies in the data analysis since it was based upon American children and adolescents. If there are population differences in the timing and overall growth of American and Marshallese children, they will be reflected in my analyses here.

Calculations of upper arm muscle and fat area are based upon the measurements of the upper arm circumference and triceps skinfolds. The assumption is that the upper arm and its components are cylindrical. The areas of cross section are calculated from the formula that yields the areas of a circle from its circumference. This technique was originally used by Best and Kuhl (1953) and Baker et al. (1965, 1958) and has been used to determine upper arm muscle, fat areas and circumferences in a number of historical studies (Frisancho 1984, Frisancho and Garn 1971, Amador et al. 1982, Anderson 1975, Frisancho 1974, Gurney and Jeliffe 1973). Of course, estimations are limited with this anthropometric approach and the degree of overestimation varies directly with the amount of adipose tissue. Skinfolds that exceed the 85th percentile for age and sex can estimate an excessive amount of body muscle. As Frisancho (1990) suggests, the nutritional assessment based upon anthropometric estimates of muscle area among the obese should be done with great caution.

Frisancho (1990) also offers ways to calculate estimated percent body fat and frame size, yet these are problematic for my Marshallese sample of school children. Frisancho (1990) does suggest a crude way to calculate estimated percent fat from skinfolds, but these regression equations were built upon adults 17 years and older. Therefore, I cannot appropriately calculate body fat percentage with my Marshallese sample relying on the sum of skinfolds. This same age limitation was present with frame size calculations. Frame size classification is limited to males and females over the age of 17. Even though frame size cannot be classified among my Marshallese sample, it should be noted that this activity could be considered inappropriate as skeletal growth is incomplete until the ages of 18-25 (Bogin 1988).

Although I have highlighted some of the limitations of using Frisancho's reference, there are a number of comparisons I can make to assess the Marshallese sample that prove useful. Tables 4.11 and 4.12 display the average measurements and calculated indices for Marshallese males and females, respectively. These include total upper arm area, upper arm muscle area, upper arm fat area, arm fat index (percent of fat), sitting height index, and the sum of skinfold thicknesses (triceps and subscapular skinfolds). The majority of these measurements do not reveal a lot in terms of Marshallese body composition until we examine calculated z-scores in comparison to the reference. As was the case for Tables 4.1 and 4.2, these tables act as potential future reference material for researchers in the Republic of the Marshall Islands. Tables 4.11 and 4.12 do contain interesting suggestions relative to the sitting height index among Marshallese children. Sitting height index is important as it reveals the proportional measurement of the axial skeleton compared to overall height. For both Marshallese males and females, the sitting height index ranged from 56.06 to 53.00%. This suggests that the average axial skeleton or torso was long and the appendicular skeleton or legs were short. In other words, the axial skeleton made up more than half of the average height for Marshallese school children. I visit this concept again later in a few paragraphs when looking at sitting height z-scores.

Tables 4.13 and 4.14 display the calculated mean z-scores for total arm area, upper arm muscle area and upper arm fat area among Marshallese males and females, respectively. One sample t-tests were used to compare statistical difference from the Frisancho (American) reference (1990). For both Marshallese males and females, the total upper arm z-scores were statistically significantly lower for each age group compared to the reference. To explore this point further, I first discuss the upper arm muscle area z-scores. Every Marshallese male age group had a statistically significantly lower z-score average compared to the reference. Although statistical significance suggests a below average muscle mass, Frisancho (1990) describes a z-score range of -1.036 to +1.030 for muscle status as “average”. Using this anthropometric classification, Marshallese males aged 5 to 10 as well as 12 year old males could be clinically considered as having average muscle mass. Males aged 11, 13 and 14 years had a muscle status described as “below average” ($-1.645 < z < -1.040$). For Marshallese females, every age except 7 year olds were statistically significantly lower in upper arm muscle area. Females aged 7 years were close to significance ($p=0.076$). Yet, again most Marshallese females had a clinical muscle status described as “average”. Only 9 year old females, on average, had a clinical classification of “below average”. Taken together, my Marshallese sample, males and females, appeared to have slightly less muscle when compared to the reference, which was not necessarily surprising considering the total arm area was smaller than the reference as well.

What was surprising was what upper arm fat area and arm fat index z-scores revealed. Frisancho (1990) again, as with muscle status, described anthropometric classifications for fat status. A z-score range of -1.036 to 0.670 is clinically considered “average” fat. The upper arm fat area z-score for every male and female age group was considered to have “average” fat. Only 5, 10, and 11 year old Marshallese males could be considered having statistically significantly lower upper arm fat area z-scores. Seven of the ten Marshallese female age groups had an upper arm fat area z-score statistically significantly lower on average. The majority of the upper arm muscle and fat area z-scores for Marshallese age groups, male and female, were considered clinically “average”. Yet, upper arm muscle area z-scores bordered around -1 SD from the mean. In addition, the upper arm fat area z-scores ranged around a quarter of a standard deviation less than the reference mean. These findings were consistent with what the arm fat index z-scores revealed about both the male and female Marshallese children. Arm fat index is a proportion of the arm fat area by total arm area. It reveals what fraction of the arm is comprised of adipose tissue. A majority of the age groups from Marshallese male and female arm indices revealed over thirty percent fat. If one turns toward the z-score averages, it can be seen that all of the Marshallese male age groups and the majority of the female age groups had z-scores above the average arm fat index of the reference (Table 4.13 and Table 4.14). Most of the Marshallese male age groups were statistically significantly higher on average when compared to the reference mean. Only three of the female age groups were statistically significantly different from the reference average.

Overall, Marshallese male and female groups from this sampled can be described as having a smaller overall total arm area and upper arm muscle area when compared to the reference. The upper arm fat areas among Marshallese males were not as deficient in adipose tissue when compared to the reference, which resulted in a higher proportion of fat in the composition of the upper arm. The upper arm fat area among Marshallese females was considered statistically significantly lower than the reference mean, but the proportion of fat could be considered higher in the composition of the upper arm as revealed by the arm fat index z-scores. The Marshallese males had a higher proportion of fat compared to the reference. One explanation for this finding may be due to the information learned from the sitting height indices. The smaller overall arm size (appendicular skeleton) may reflect the findings here.

Tables 4.15 and 4.16 reveal the average calculated body composition z-scores for sitting height, the sitting height index, elbow breadth, and mid-upper arm circumference. These measurements include all of the Marshallese age groups for males and females, respectively. For a review of average sitting height, elbow breadth, and mid-upper arm circumference measurements for Marshallese males and females by age, refer to Tables 4.1 and 4.2. I have already explored sitting height somewhat with our discussion of the sitting height index calculated in Tables 4.1 and 4.2. The sitting height and sitting height index z-scores allow me to make some more statements about my Marshallese sample. Taking sitting height into account first, the average z-scores for Marshallese males were statistically significantly lower when compared to the reference mean. This trend was similar for Marshallese females at the age of 7, although arguably, a trend towards significance was seen for 5 and 6 year old Marshallese females as well. This data illustrates that my Marshallese sample had a shorter axial skeleton on average. Returning to my thoughts on sitting height index, which, again, is a proportion of the axial skeleton to the overall height of the individual, average z-scores were well above the reference mean for both males and females after the age of 5. Even though a statistical difference was not calculated for these male and female 5 year old groups, they were both above the reference mean. So, although Marshallese children in my sample had shorter axial skeletons compared to the Frisancho (1990) reference, their sitting height index was still significantly greater than the reference mean. In other words, the proportion of the axial skeleton accounts for more of the Marshallese height than their appendicular skeleton does when compared to the American reference.

Elbow breadth also offers another glimpse into what is seen with the skeleton of the Marshallese sample. Although Frisancho (1990) does offer a calculation of Frame Index, which is a proportion of elbow breadth to height, none of my Marshallese males were tall enough to be compared or categorized. The Marshallese females did have some individuals who were tall enough for categorization, but due to the lack of application here, only z-scores were relied upon to make a statement regarding the robustness of the Marshallese skeleton in my sample. Every age group, for Marshallese males and females, had a statistically significantly lower average z-score when compared to the reference mean. In fact, these averages ranged from -1.5 to -1.83 z-scores across the age groups. The Marshallese child and adolescent skeleton could be classified as small to extremely small when compared to the American reference.

The final measurement explored in these tables (4.15 and 4.16) includes the mid-upper arm circumference z-score. Every Marshallese male and female age group was found to be statistically significantly lower on average when compared to the reference mean. This measurement is used to calculate total upper arm area, and subsequently, upper arm muscle and fat area in conjunction with skinfolds, so a further assessment was not explored. But, the findings were not surprising considering what was found with the total upper arm area z-scores.

Three skinfold measurements were taken with the Marshallese sample. These included the triceps, subscapular, and suprailliac skinfolds. Suprailliac skinfolds have been used more commonly in today's research as a way to diagnosis metabolic syndrome and levels of obesity (Golec 2014, Leal et al. 2014, Nagy et al. 2014). Unfortunately, though, there was no reference data to assess this measurement for the Marshallese sample. My analytical focus remained on the triceps and subscapular skinfolds using Frisancho's (1990) reference data. In principle, these skinfolds give a clue to not only how much adipose tissue an individual had, but they can also allow for observation into how fat was distributed among the axial and appendicular skeleton. Tables 4.17 and 4.18 present the average calculated body composition z-scores for triceps skinfolds, subscapular skinfolds, and the sum of skinfold thickness. Marshallese males had only one age group (12 year olds) that was statistically significantly higher on average when compared to the American reference mean for triceps skinfolds. The other age groups for this measurement center around the reference mean. These results were not seen for the subscapular skinfold. Marshallese males, on average, consistently had z-scores above the mean of the reference. A statistically significant difference was found after the age of 7 with the age group 13 being the exception. This suggests that Marshallese males in my sample carried more adipose tissue on their axial skeleton than their appendicular skeleton. Turning toward the female sample, one can see somewhat similar results with the triceps and subscapular skinfold z-scores. Most of the female age groups have average z-scores just below the reference mean with only 5, 11, and 14 year olds statistically significantly lower for the triceps skinfold. Just like the Marshallese males, though, one sees a similar picture with the subscapular skinfolds. All Marshallese female age groups had an average z-score above the reference mean. Females aged 5, 11, and 14 years did not have a statistically significant difference. Again, these results suggest Marshallese females in my sample carried more adipose tissue on their axial skeleton compared to their appendicular skeleton.

Frisancho (1990) also allows for assessment or categorization of fat status, much like with mid upper arm fat area and index, by summing the skinfold thicknesses of the triceps and subscapular measurements. With the exception of 5 year olds, every Marshallese male age group had an average z-score above the reference mean. Although this is clinically relevant, only 8 and 12 year old age groups were found to be statistically significantly higher than the reference mean. Frisancho (1990) describes “average” fat status as a z-score ranging between -1.036 to 0.670. Using this range, every male age group in my sample could be described as having an “average” fat status. The application of this fat status categorization continued with every Marshallese female age group as well. The interesting aspect of the female groups was that not one age group differed statistically from the reference mean. These results align with learning that the Marshallese axial skeleton was taller, proportionately, when compared to the American reference. (And they apparently carried more fat on their axial skeletons.) Yet, the confounding issue the data has demonstrated is that Marshallese were smaller or shorter on average compared to the American reference.

Although the Marshallese male and female age groups can be classified as having “average” fat status based upon sum of triceps and subscapular skinfold thicknesses, caution should be expressed with how these findings are interpreted. The analysis of the Marshallese sample has revealed shorter heights, smaller skeletal frames, and less muscle mass when compared to the American reference. To not find similar results with adipose tissue suggests that Marshallese children and adolescents in my sample may actually have had an above average fat status. Unfortunately, Frisancho (1990) does not offer an exploration of the proportion of the skinfolds or fat area to any other anthropometric measurement.

Yet, Frisancho (1990) does allow for a comparison of upper arm muscle area by height for males and females. Table 4.19 includes the upper arm muscle area by height z-scores for both Marshallese males and females. Before any interpretation is made here though, a caveat should be discussed. Frisancho’s (1990) table including means, standard deviations and percentiles of upper arm muscle area by height is divided first by age groups for males and females. The male categories include 2 to 11 years of age with a range of heights from 87cm to 164cm and 12 to 17 years of age with a range from 141cm to 194cm. The female categories include 2 to 10 years of age with a height range from 87cm to 158cm and 11 to 17 years of age with a range of 141cm to 182cm. A problem occurred when focusing on these second age ranges because there were males and females who had a height less than 141cm. A choice was made to exclude these Marshallese participants even though their height was represented in the younger age groups. Therefore, caution should be taken with the interpretation.

With this caveat, one can clearly see that the mean z-score for each Marshallese male and female age group centers close to the reference mean for upper arm muscle area by height. The only statistically significantly different age groups found, when compared to the reference, were 7 and 13 year old males. Proportionately speaking then, I can say that Marshallese males and females in my sample had average muscle mass for their height. The problem, again, is what would happen to my analysis when those shorter adolescent males and females were taken into account. Unfortunately, I cannot address this matter as it would not be appropriate to take these older adolescents and compare them to their height listed in the younger American age group of the reference.

Historical Comparisons

Pilot Study

Going forward, my sample is referred to as the 2008-2009 Marshallese sample at times to distinguish it from other nutritional assessment studies completed in the past. The 2008-2009 Marshallese sample shows that adolescent males and females were statistically significantly lower in average height and weight than the reference data used for comparisons. The difference in average height (~3rd percentile) was much more pronounced than average weight (~15th percentile) when compared to the WHO 2007 reference. Because the children were more stunted than underweight, their calculated BMI average was higher and fell along the reference mean for every age. One could suggest that these BMIs revealed proportionate dimensions for height and weight in this population and the Marshallese children in our sample were as Stini

(1971) suggests “small but healthy”. The other suggestion is that these Marshallese children were nutritionally deficient in both height and weight, and therefore the BMI calculations introduced bias or some error in terms of nutritional assessment. This quandary is further teased apart in subsequent chapters. But, before I move on and begin to interpret the findings from my Marshallese nutritional assessment, it would be useful to compare my findings to those described in earlier studies. Such comparisons can possibly illustrate how Marshallese child growth has changed over time.

I first turn my attention to the pilot study conducted in 2006, which, it will be recalled, was the impetus in completing this 2008-2009 nutritional assessment. As stated in the introductory chapter, the pilot study measurement data was collected by a Marshallese field team composed of nurses and a public health advocate. Major issues were present with the pilot study as there were no repeated measures to verify measurement precision and reliability among the health workers who collected the data. These health workers also did not employ standardized measurement techniques when collecting height or weight. Height and weight was collected among a group of 4th grade public and private school female and male children living on Majuro Atoll. Children ranged in age from 8 to 14 years of age. The data collected in 2006 was compared to the CDC 2000 growth references since the WHO 2007 reference was non-existent at the time. Here, the findings from the pilot study were recalculated using the newer WHO 2007 reference for comparison. Another issue with the pilot data was that only the year of age was recorded for each child by the Marshallese health workers. For instance, a child might have been listed as 9 years old, when in reality, the child was 9 years and 10 months of age. The WHO 2007 reference divides growth reference data down to each month of age. There is no accurate way to calculate z-scores in this instance and so, for example, the reference value for 9 years and 6 months was used for all 9 year olds. This same method was used for the other ages from the pilot data. Height-for-age, weight-for-age, and BMI-for-age z-score averages were calculated from the pilot study data and compared to the 2008-2009 Marshallese sample. Children aged 8 and 14 were omitted from this analysis as there was only one or two children available from the pilot study for analysis. These comparisons can be seen in Tables 4.20, 4.21, and 4.22.

Table 4.20 shows the comparison of height-for-age z-score averages for both males and females. As one can see, the pilot study data for ages 9 and 13 have small sample sizes and the comparison with these age groups should be interpreted with caution. Males aged 12 years were the only group to show a statistically significant difference in average height-for-age z-scores. The females had three of the five age groups showing statistically significant differences for average height-for-age z-scores. One interesting point to consider was the directional difference in average height-for-age z-scores as age progresses. Both males and females show a decrease in average growth when comparing the 2006 pilot study data to the 2008-2009 nutritional assessment. This trend reverses, or increases, for females at age 11 and for males at age 12. Although there were not many age groups to consider here because of the sample size issues already discussed, one should question whether the reference itself was causing this trend. It may have been due to the timing of puberty and its effect on growth in the American sample used to construct the reference. Unfortunately, this consideration is conjecture due to the issues highlighted before with recorded age in the 2006 pilot study.

Table 4.21 displays the comparison of weight-for-age z-score averages among the 2006 pilot study data and the 2008-2009 nutritional assessment. Remembering that the 2007 WHO growth reference only extends to the age of 10 years, only 9 year olds are displayed here. Although I did not see any statistically significant differences among the assessments for males and females, the sample size for this age group was suspect. Table 4.22 compares the body mass index-for-age z-score averages calculated from the 2007 WHO growth reference among the 2006 and 2008-2009 studies. A statistically significant difference was found for the average body mass index-for-age z-score for 12 year old males and females as well as 13 year old females. Otherwise, there was not much of a difference found among the two data sets for the average body mass index-for-age z-score. A pattern does not necessarily emerge like it did with height-for-age z-scores. Overall, the pilot study data from 2006 does seem similar to the results found with the 2008-2009 nutritional assessment, but the issues pointed out earlier with age (e.g., stated vs. actual age) and data collection methodology may have been enough to explain any significant differences found here. For this reason, the pilot study data was not included in the entire sample for the 2008-2009 nutritional assessment. But, like any pilot study attempts to accomplish, it led to the 2008-2009 assessment with an attempt to correct methodological issues as well as confirm findings.

Previous Nutritional Assessments from the Marshall Islands

In chapter 2, four previous nutritional assessments were introduced along with records from Majuro Hospital that discussed rates of malnutrition among Marshallese infants, children and adolescents (Hughes et al. 2004, Gammino 2001, Gittelsohn 1998, Alfred 1991). The table presented in chapter 2 has been reproduced here along with rates calculated from the 2008-

2009 nutritional assessment (Table 4.23). One issue that should be considered is the definition or classification of underweight, overweight, and obesity among the Marshallese nutritional assessments. The study completed by Alfred and Palafox in 1991 along with Majuro Hospital records used the weight-for-age index to classify underweight and overweight among Marshallese youth. The other studies began to define underweight, overweight, and obesity based on the more frequent and preferred use of body mass index-for-age beginning in the 1990's. Another issue to consider before making any comparison of malnutrition rates was the use of growth references. As I have reviewed in earlier chapters, the WHO 2007 reference was used in this dissertation analysis and it could have a tendency to report less stunting compared to the CDC 2000 reference and might over-report rates of overweight and obesity.

It appears that the stunting rate among the 2008-2009 sample (34.6%) is similar to what Gittelsohn and Alfred found with the similar age ranges in 1998 (35.0%) and 1991 (35.0%). There is some concern here as the 2008-2009 sample ends at the age of 14 and Gittelsohn's sample includes adolescents up to the age of 18. The Alfred sample does not include the ages of 5 and 6. Despite these age issues with the data, the stunting rate appears to be fixed around this 35.0% mark. Hughes et al. (2004) included two separate samples of children from the communities of Rita and Laura on Majuro Atoll. The rates of stunting among these two communities were 25.3% and 32.5%, respectively. It was noted in Chapter 2 that Gittelsohn (1998) suggested urban areas provide better access to nutritional foods and this point was especially true when considering socioeconomic status. Yet, Hughes et al. (2004) show two communities on Majuro Atoll that had lower rates of stunting. One thing to consider with the 2008-2009 sample's malnutrition rate is that multiple communities from Majuro Atoll were represented, including Rita and Laura. Gittelsohn (1998) and Hughes et al. (2004) examined the nutritional status of the whole sample, yet they displayed data outcomes looking at populations within the sample. This exercise is conducted in the next chapter as I begin to explore similarities and differences in growth among private and public school children.

The rates of stunting for children under the age of five did not reveal a common pattern. The rate of stunting among children aged birth to 5 years was 24.0% in children sampled in the Alfred (1991) study. Gammino's (2001) rate of stunting among this age cohort was 39.3%. Gammino (2001) suggested that chronic malnutrition was severe in infancy and so Marshallese children were constantly trying to "catch-up" in growth. This point is revealed by the somewhat lower rates of stunting in childhood and adolescence found among the Alfred (1991), Gittelsohn (1998), Hughes et al. (2004) and the 2008-2009 sample data. If one was to follow the line of logic where Alfred's stunting rate was more accurate, the assessment could suggest that chronic malnutrition has been a constant and accumulating battle for children in the Marshall Islands. Alfred's study does not specifically discuss the distribution of sampled children among urban and rural locations or atolls. I suggest that the answer to varying stunting rates between Gammino (2001) and Alfred's (1991) studies lies there.

Intriguing results emerged when examining malnutrition rates calculated by weight-for-age and BMI-for-age. The 2008-2009 sample found only a half percent of the children classified as underweight or exhibiting mild thinness. This rate was extremely different when comparing rates reported by Hughes et al. (2004) or Gittelsohn (1998). This point was true with the Alfred (1991) study as well. The large difference may be related to the issues highlighted with the use of the WHO 2007 reference. Alfred (1991) found a similar overnutrition rate among younger children (birth to 5 years), but as already stated, this rate was calculated from weight-for-age. Two things are suggested for the explanation of these varying rates. The first involves the varying use of different growth references among the samples. The second is that the children on Majuro Atoll are actually evidencing a secular increase in the amount of overweight and obesity present among the children sampled. This might explain why hardly any of the children in the 2008-2009 sample were classified as underweight/thin and a majority of the children are classified as having normal weight. One major point that should be reviewed here is the issue of average height-for-age and weight-for-age among the Marshallese children sampled in the 2008-2009 sample. As discussed earlier, Marshallese children were more stunted than they were underweight. The resulting proportion of the calculated body mass index makes the children appear to have normal body mass indices when compared to the reference. One possible critique of the WHO 2007 growth reference is that they should consider weight-for-age for all ages to assist with teasing this situation apart. Again, Jamison (1995) has made this point before.

To further explore the secular differences in malnutrition rates, an in-depth comparison was made between Gittelsohn's 1998 and the 2008-2009 sample data. One difference with Gittelsohn's (1998) study was that collected child growth data was included from remote and urban atolls. Over half of this sample came from the most urban areas of Majuro Atoll (54%) though. Yet, Gittelsohn (1998) also notes that he did not find differences in stunting by location. Table 4.24 displays the stunting, wasting and low weight-for-age percentages for both of the samples. The data is presented in the way Gittelsohn (1998) did in his study with age groups divided into birth to 4.9, 5 to 9.9, and 10 to 17.9 years of age. One issue here is that the 2008-

2009 sample stops at the age of 14. Therefore, if malnutrition is an issue that continues to exhibit itself the older the Marshallese children become, as Gittelsohn (1998) suggests, the rates of malnutrition may not fully express themselves in the 2008-2009 sample. One other important note here is that wasting was not calculated among the 2008-2009 sample as body mass index is a much more acceptable representation of the height and weight ratio today. Even with these points highlighted, similarities can be seen in the rate of stunting between the two samples. Another thing to note here is the increase seen with stunting in the 2008-2009 Marshallese sample. Both males and females revealed a much larger percentage of stunting in the adolescent (10-17.9 years of age) group. This trend was similar to what Gittelsohn (1998) suggests. The older a Marshallese age group, the more prominent the effect of malnutrition is seen.

Gittelsohn's (1998) sample revealed that a decrease in the prevalence of stunting and low weight-for-age from the birth-4.9 years age group to the 5-9.9 years age group. Gittelsohn (1998) suggests that this may be due to catch-up growth. Although the timing and degree of catch-up growth among stunted children is open to debate, studies of children from a variety of settings suggest that catch-up growth may indeed occur among children until adolescence given favorable environmental and nutritional circumstances. In most cases, the environmental and nutritional circumstances among Marshallese are not going to change. Therefore, the slowing rate of growth during the 5-9.9 age range may be just enough to allow for this catch-up in growth with all environmental and nutritional circumstances remaining static. Gittelsohn (1998) also attributes this decrease to possible attendance in schools where school lunch programs were introduced as well as to the ability of older children to be better at procuring food for themselves.

Once the children reach adolescence (10-17.9 years of age), the rate of growth in the reference population would substantially increase due to the influence of puberty and the result was that rates of stunting substantially increase among both samples here. Low weight-for-age increased substantially in the 2008-2009 sample as well as among the Gittelsohn (1998) sample. The increase in stunting was greatest among males in Gittelsohn's (1998) study, with almost a 20 percent increase compared to females (6%), though he stated that this is partly attributable to the higher prevalence of stunting among females (35.2%) in the previous age cohort. This finding was reversed for the 2008-2009 sample where the rate of stunting was almost double for females when compared to males. The prevalence of low weight-for-age among males in Gittelsohn's (1998) study also demonstrated a large increase (11%) compared to that of females in the same age group (2%). Gittelsohn (1998) stated that he was unclear on how to explain the increases in prevalence among this age group. He suggested it may be due to females undergoing menarche or boys being more active and hence having a larger energy expenditure.

Looking at Table 4.25, a comparison of overweight and obesity rates among the Gittelsohn (1998) samples and the 2008-2009 sample can been seen. Unlike the 2008-2009 Marshallese sample, body mass index did not reveal overweight and obesity to be a problem among Marshallese youth in Gittelsohn's (1998) study. As Gittelsohn described (1998: p. 34), obesity tends to be an "adulthood problem". Almost a third of all adult males and females were classified as overweight. A substantial number of adults were classified as obese based on their body mass index, with more women being obese than men. He continued by stating that an overall look at the sampling in his study revealed a demarcation of 20-24 year olds showing a higher proportion of men and women classified as overweight, again with overweight and obesity being more pronounced in women than in men. Obesity rates were similar between urban and remote areas, even though, as I explore later in the investigation here, food differs greatly within and across urban settings. Rates of overweight and obesity were present among the 2008-2009 Marshallese sample and they could be considered a more recent problem with Marshallese children.

Historical Growth Data from Other Pacific Populations

Chapter 2 of this dissertation reviewed a number of historical growth data from other populations in the Pacific. These data were presented in tables pulled from Eveleth and Tanner's (1990) Worldwide Variation in Human Growth and the 2008-2009 Marshallese data have been added to these tables (Tables 4.26 – 4.33) for comparison. These comparisons are briefly discussed here. Taken together, Samoans on Hawaii and American Samoa and Australian Aborigines were the tallest among Pacific Islander groups reviewed here. The mean heights of Samoans fell within or close to the range seen in European children (Eveleth and Tanner 1990). Marshallese children were much shorter at every age compared to Hawaiian and American Samoans except for 11 year old males. Marshallese boys and girls appeared to be taller, on average, than many of the Melanesian populations presented here, but this trend disappeared around the age of twelve.

As for weight, Samoan children were mostly heavy or heavier than Europeans, yet at some ages, Western Samoans were lighter (Eveleth and Tanner 1990). The progression of weight follows with Samoan children in Hawaii being the heaviest, American Samoan being the next heaviest and those in Western Samoa the lightest. Larger size is said to be associated with increased modernization as Samoans move from farming and fishing on Samoa to skilled and professional jobs on Hawaii (Eveleth and Tanner 1990). As for the 2008-2009 Marshallese sample, they tended to weigh less, on average, when compared to the other Polynesian populations presented. Yet, compared to most of the Melanesian populations presented, they tended to weigh more when considering each age group.

There is little data on sitting height for Pacific Island populations. Australian Aborigines had the longest leg to trunk length of any population. The Bundi had very short stature, but they had longer legs in relation to trunk length than children surveyed from London. This point was reflected among the 2008-2009 Marshallese sample as well. Compared to the data available for other Pacific populations, Marshallese children tended to have a larger sitting height on average when compared to Australian aborigines and populations from Papua New Guinea. Yet, Maori from New Zealand still displayed larger sitting height measurements than the 2008-2009 Marshallese sample.

Table 4.31 displays the average mid-upper arm circumferences for the 2008-2009 Marshallese sample and three samples from Papua New Guinea. In every case for sex and age, Marshallese children had larger average measurements. Tables 4.32 and 4.33 display the average measurements of triceps and subscapular skinfolds. There are skinfold measurements from the three Papua New Guinea populations as well as Tokelau Islanders living on Tokelau and New Zealand (Eveleth and Tanner 1990). The Bundi, who were smaller than the Manus in all other measurements, had larger triceps and subscapular skinfolds than the Manus and larger triceps skinfold than the Wopkaimin. The Tokelauans had larger skinfolds than the Bundi at most ages, and in turn, the Tokelauans in New Zealand had means that exceeded all the others. The 2008-2009 Marshallese sample tended to have similar or larger measurements than the reported Tokelauan skinfolds, depending on sex and age. The Tokelauan and Marshallese mean subscapular skinfolds exceeded those of the United States reference (NCHS, WHO 2007) at many ages (Ramirez and Mueller 1980). As Ramirez and Mueller (1980) suggested among Tokelauans living in New Zealand, this might serve as an example of an increase in trunk adiposity with migration and modernization in a western culture.

Population Assessment and Further Directions

This dissertation's nutritional assessment shows that malnutrition is an evident problem among Marshallese school children on Majuro Atoll. Overall, the average rate of stunting among all children sampled in the 2008-2009 sample was 34.6%. The females had a stunting rate of 38.7% compared to the sampled male rate of 31.0%. The use of BMI and WHO classifications revealed low rates of overweight and obesity among males and females and an even lower rate of underweight/thinness among the 2008-2009 sample compared to historical nutritional assessments completed in the Marshall Islands.

Gittelsohn (1998) and Hughes et al. (2004) propose an interesting way to examine nutritional status. They examined the nutritional status of the whole sample as I have done here, and yet, they also displayed data outcomes looking at sub-populations within the sample. In the next chapter, the analysis follows these examples by exploring growth differences and similarities between public and private school children. As Gittelsohn (1998) has stated, children living in urban areas may have better access to a variety of foods, depending on the socioeconomic status of the child and their family. The next chapter of this dissertation explores this suggestion as well as confirms the results from the 2006 pilot study.

Chapter 4 Tables and Figures

Table 4.1: Anthropometrics of Male Marshallese School Children*

Age (n)	Stature (cm)	Sitting Height (cm)	Weight (kg)	Body Mass Index	Elbow Breadth (cm)
5 (7)	107.10 (2.88)	59.70 (1.91)	17.77 (1.06)	15.49 (0.58)	4.35 (0.18)
6 (22)	110.37 (5.28)	61.75 (3.12)	19.25 (3.06)	15.74 (1.63)	4.40 (0.29)
7 (32)	116.76 (5.25)	64.91 (2.70)	21.25 (3.13)	15.54 (1.46)	4.60 (0.21)
8 (44)	121.57 (4.96)	66.87 (2.21)	24.22 (4.12)	16.29 (1.86)	4.78 (0.27)
9 (37)	125.70 (5.78)	68.65 (2.65)	27.02 (6.25)	16.93 (2.48)	5.02 (0.36)
10 (40)	130.66 (5.78)	70.72 (3.01)	28.93 (5.24)	16.83 (1.95)	5.15 (0.33)
11 (45)	134.58 (5.05)	72.17 (2.87)	31.67 (4.96)	17.43 (2.11)	5.23 (0.29)
12 (40)	139.82 (6.76)	74.99 (4.02)	37.82 (10.33)	19.09 (3.71)	5.59 (0.45)
13 (25)	143.42 (8.09)	76.16 (3.87)	36.91 (6.67)	17.84 (1.75)	5.76 (0.40)
14 (16)	152.21 (8.51)	80.70 (5.26)	44.94 (7.95)	19.31 (2.34)	6.03 (0.37)

Age (n)	Mid-Upper Arm Circumference (cm)	Triceps Skinfold (mm)	Subscapular Skinfold (mm)	Suprailiac Skinfold (mm)
5 (7)	16.26 (0.80)	8.64 (1.31)	5.46 (0.77)	6.61 (1.44)
6 (22)	17.05 (1.57)	9.47 (2.97)	6.89 (3.52)	8.32 (4.34)
7 (32)	17.15 (1.45)	8.98 (3.48)	7.36 (5.42)	7.63 (4.15)
8 (44)	18.26 (1.58)	10.06 (3.74)	8.04 (4.46)	9.94 (6.17)
9 (37)	19.29 (2.51)	11.39 (5.25)	9.36 (6.65)	10.41 (6.64)
10 (40)	19.57 (2.09)	11.04 (4.21)	9.71 (5.02)	10.99 (6.21)
11 (45)	20.27 (2.09)	12.22 (4.22)	10.52 (4.50)	12.43 (6.30)
12 (40)	22.27 (3.80)	14.87 (7.74)	14.63 (9.78)	16.37 (10.86)
13 (25)	21.27 (1.83)	11.62 (4.41)	9.47 (3.64)	10.98 (5.72)
14 (16)	23.16 (2.50)	11.20 (4.57)	12.56 (5.86)	11.95 (5.35)

*All measurements listed are representations of the mean (standard deviation). Measurements highlighted in yellow are not normally distributed.

Table 4.2: Anthropometrics of Female Marshallese School Children*

Age (n)	Stature (cm)	Sitting Height (cm)	Weight (kg)	Body Mass Index	Elbow Breadth (cm)
5 (6)	106.59 (3.51)	59.73 (1.81)	17.3 (1.43)	15.21 (0.58)	4.18 (0.25)
6 (15)	110.72 (5.81)	61.33 (3.20)	19.18 (2.26)	15.61 (1.02)	4.30 (0.22)
7 (27)	116.26 (5.44)	64.32 (2.46)	21.08 (2.46)	15.57 (0.99)	4.43 (0.23)
8 (39)	119.27 (6.25)	65.73 (3.26)	22.96 (4.73)	16.01 (1.85)	4.51 (0.35)
9 (38)	125.75 (4.98)	68.76 (2.63)	26.20 (3.92)	16.50 (1.66)	4.77 (0.28)
10 (40)	128.72 (7.17)	69.83 (3.48)	28.07 (5.34)	16.83 (2.02)	4.85 (0.35)
11 (34)	137.20 (7.67)	74.18 (4.04)	32.91 (6.53)	17.33 (2.07)	5.12 (0.39)
12 (35)	141.50 (5.82)	76.54 (3.17)	38.99 (8.05)	19.35 (3.02)	5.28 (0.31)
13 (20)	146.28 (5.20)	79.16 (2.60)	42.60 (7.98)	19.84 (3.10)	5.40 (0.26)
14 (8)	146.50 (11.31)	78.91 (5.58)	42.31 (10.85)	19.42 (2.00)	5.44 (0.39)
Age (n)	**Mid-Upper Arm Circumference (cm)**	**Triceps Skinfold (mm)**	**Subscapular Skinfold (mm)**	**Suprailiac Skinfold (mm)**	
5 (6)	16.64 (0.31)	9.13 (0.38)	8.67 (2.04)	8.25 (2.25)	
6 (15)	16.86 (0.93)	10.18 (2.26)	8.23 (2.13)	10.02 (3.77)	
7 (27)	17.78 (2.33)	10.40 (1.92)	8.41 (2.41)	9.96 (3.18)	
8 (39)	18.07 (1.98)	11.46 (4.06)	9.42 (3.81)	12.15 (5.28)	
9 (38)	18.73 (2.51)	12.68 (3.18)	10.91 (3.89)	13.20 (4.62)	
10 (40)	19.43 (2.04)	13.24 (4.36)	12.23 (6.06)	14.38 (6.50)	
11 (34)	19.89 (2.24)	12.11 (3.58)	12.27 (5.53)	14.15 (5.90)	
12 (35)	21.97 (2.79)	14.47 (5.26)	16.10 (7.21)	16.62 (6.20)	
13 (20)	22.99 (2.73)	16.52 (6.33)	16.38 (5.99)	19.58 (6.67)	
14 (8)	22.41 (2.14)	13.84 (3.49)	15.93 (5.11)	16.44 (4.72)	

*All measurements listed are representations of the mean (standard deviation). Measurements highlighted in yellow are not normally distributed.

Table 4.3: Male and Female Body Fat Percentage*

Age Group	Body Fat %			
	Male		Female	
	Mean (SD)	**n**	**Mean (SD)**	**n**
5	15.46 (3.90)	7	8.65 (3.46)	5
6	15.82 (3.30)	22	9.13 (5.49)	15
7	15.54 (2.92)	32	12.30 (4.84)	27
8	15.28 (3.37)	44	12.81 (6.05)	37
9	15.10 (5.14)	37	11.66 (5.14)	37
10	13.76 (3.64)	40	12.65 (6.86)	39
11	13.83 (3.74)	44	13.01 (6.53)	33
12	14.86 (7.21)	40	16.80 (7.14)	35
13	10.49 (3.38)	24	18.88 (8.19)	20
14	10.08 (4.32)	16	17.31 (7.13)	8

*All measurements listed are representations of the mean (standard deviation). Measurements highlighted in yellow are not normally distributed.

Table 4.4: Male Height-for-Age (HAZ) Z-scores and WHO Categorization*

Age (n)	Height for Age Z-score				HAZ Categorization									Age (n)
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (7)	-1.39	0.50	-7.37	< 0.001*			1	4	2					**5 (7)**
6 (22)	-1.68	0.92	-8.58	< 0.001*		1	5	12	4					**6 (22)**
7 (32)	-1.40	0.87	-9.11	< 0.001*		1	8	11	12					**7 (32)**
8 (44)	-1.46	0.84	-11.55	< 0.001*		1	10	21	12					**8 (44)**
9 (37)	-1.56	0.92	-10.31	< 0.001*		1	11	19	6					**9 (37)**
10 (40)	-1.51	0.86	-11.13	< 0.001*		2	10	15	13					**10 (40)**
11 (45)	-1.62	0.68	-15.97	< 0.001*		1	11	27	6					**11 (45)**
12 (40)	-1.76	0.86	-12.87	< 0.001*		3	11	19	7					**12 (40)**
13 (25)	-2.07	1.17	-8.81	< 0.001*	1	3	10	8	2	1				**13 (25)**
14 (16)	-1.79	1.12	-6.35	< 0.001*		2	3	8	3					**14 (16)**

Stunted	

*p < 0.05, statistically significant

Table 4.5: Female Height-for-Age (HAZ) Z-scores and WHO Categorization*

Age (n)	**Height for Age Z-score**				**HAZ Categorization**									**Age (n)**
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (6)	-0.98	0.87	-2.76	0.04*			1	2	3					**5 (6)**
6 (15)	-1.47	1.03	-5.53	< 0.001*		1	4	4	6					**6 (15)**
7 (26)	-1.24	0.79	-7.96	< 0.001*			5	9	12					**7 (26)**
8 (39)	-1.68	0.97	-10.77	< 0.001*		3	13	14	9					**8 (39)**
9 (38)	-1.55	0.68	-14.00	< 0.001*			11	19	8					**9 (38)**
10 (40)	-1.89	1.00	-11.93	< 0.001*		6	14	15	5					**10 (40)**
11 (34)	-1.64	1.08	-8.82	< 0.001*	1	2	11	8	12					**11 (34)**
12 (35)	-1.79	0.82	-12.91	< 0.001*		3	11	15	6					**12 (35)**
13 (20)	-1.73	0.75	-10.32	< 0.001*			9	8	3					**13 (20)**
14 (8)	-2.02	1.60	-3.57	0.01*		3	3		1	1				**14 (8)**

Stunted

*p < 0.05, statistically significant

Table 4.6: Male Weight-for-Age Z-scores and WHO Categorization

Age (n)	Weight for Age Z-score				WAZ Categorization									Age (n)
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (7)	-0.81	0.45	-4.78	0.003*				3	4					**5 (7)**
6 (22)	-1.01	1.07	-4.43	< 0.001*			5	6	10		1			**6 (22)**
7 (32)	-1.01	0.87	-6.57	< 0.001*			3	14	14		1			**7 (32)**
8 (44)	-0.86	1.14	-4.97	< 0.001*		1	3	18	18	3	1			**8 (44)**
9 (37)	-0.84	1.20	-4.25	< 0.001*			3	16	15	2		1		**9 (37)**
10 (40)														**10 (40)**
11 (45)														**11 (45)**
12 (40)														**12 (40)**
13 (25)														**13 (25)**
14 (16)														**14 (16)**

Underweight	

*p < 0.05, statistically significant

Table 4.7: Female Weight-for-Age Z-scores and WHO Categorization

Age (n)	**Weight for Age Z-score**				**WAZ Categorization**									**Age (n)**
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (6)	-0.65	0.68	-2.34	0.07				2	4					**5 (6)**
6 (15)	-0.82	0.84	-3.78	0.002*			1	5	9					**6 (15)**
7 (26)	-0.75	0.64	-5.97	< 0.001*				11	15					**7 (26)**
8 (39)	-1.05	1.06	-6.17	< 0.001*		1	3	20	13	1	1			**8 (39)**
9 (38)	-0.91	0.85	-6.58	< 0.001*			2	17	17	2				**9 (38)**
10 (40)														**10 (40)**
11 (34)														**11 (34)**
12 (35)														**12 (35)**
13 (20)														**13 (20)**
14 (8)														**14 (8)**

Underweight	

*p < 0.05, statistically significant

Table 4.8: Male Body Mass Index-for-Age Z-scores and WHO Categorization

Age (n)	BMI for Age Z-Score				BMIZ Categorization									Age (n)
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (7)	0.15	0.45	0.88	0.41					7					**5 (7)**
6 (22)	0.17	0.94	0.83	0.42				1	20	1				**6 (22)**
7 (32)	-0.13	0.82	-0.91	0.37				4	27		1			**7 (32)**
8 (44)	0.11	0.99	0.76	0.45				4	33	5	1	1		**8 (44)**
9 (37)	0.19	1.01	1.17	0.25				2	29	3	2	1		**9 (37)**
10 (40)	-0.08	0.98	-0.51	0.61			1	8	24	7				**10 (40)**
11 (45)	-0.04	1.02	-0.29	0.77				10	26	8	1			**11 (45)**
12 (40)	0.22	1.21	1.17	0.25			1	5	24	7	2	1		**12 (40)**
13 (25)	-0.44	0.88	-2.47	0.02*			1	6	16	1				**13 (25)**
14 (16)	-0.16	0.92	-0.70	0.49				4	10	2				**14 (16)**

Severe Thinness	(red)
Thinness	(orange)
Overweight	(green)
Obesity	(blue)

*p < 0.05, statistically significant

Table 4.9: Female Body Mass Index-for-Age Z-scores and WHO Categorization

Age (n)	BMI for Age Z-Score				BMIZ Categorization									Age (n)
	Mean	Standard Deviation	t	p	-4	-3	-2	-1	0	1	2	3	4	
5 (6)	-0.04	0.40	-0.25	0.81					6					**5 (6)**
6 (15)	0.13	0.60	0.83	0.42					14	1				**6 (15)**
7 (26)	-0.02	0.56	-0.22	0.83				1	25					**7 (26)**
8 (39)	-0.03	0.82	-0.23	0.82				4	31	3	1			**8 (39)**
9 (38)	-0.01	0.76	-0.08	0.93				2	31	5				**9 (38)**
10 (40)	-0.13	0.93	-0.91	0.37				9	28	2	1			**10 (40)**
11 (34)	-0.26	0.89	-1.67	0.10				8	23	3				**11 (34)**
12 (35)	0.21	0.90	1.40	0.17				2	28	3	2			**12 (35)**
13 (20)	0.07	0.98	0.32	0.75				2	14	3	1			**13 (20)**
14 (8)	-0.21	0.73	-0.82	0.44				1	7					**14 (8)**

Severe Thinness	
Thinness	
Overweight	
Obesity	

*p < 0.05, statistically significant

Table 4.10: International Obesity Task Force Body Mass Index Categorization

BMI	Category
16	Thinness Grade 3
17	Thinness Grade 2
18.5	Thinness Grade 1 (Unofficial Asian Cut-Off)
18.6-22.9	Normal
23	Overweight (Unofficial Asian Cut-Off)
25	Overweight
27	Obesity (unofficial Asian Cut-Off)
30	Obesity
35	Morbid Obesity

Table 4.11: Body Composition Measurements for Marshallese Males*

Age (n)	Total Upper Arm Area *Mean (Standard Deviation)*	Upper Arm Muscle Area *Mean (Standard Deviation)*	Upper Arm Fat Area *Mean (Standard Deviation)*
5 (7)	21.09 (2.09)	14.65 (1.76)	6.44 (1.03)
6 (22)	23.33 (4.70)	15.85 (2.30)	7.47 (3.12)
7 (32)	23.58 (4.44)	16.39 (1.57)	7.19 (3.59)
8 (44)	26.74 (4.83)	18.21 (2.07)	8.52 (3.77)
9 (37)	30.12 (9.09)	19.79 (3.33)	10.33 (6.56)
10 (40)	30.84 (6.91)	20.75 (2.99)	10.09 (4.73)
11 (45)	33.06 (7.03)	21.61 (3.23)	11.44 (4.79)
12 (40)	40.62 (15.03)	24.92 (5.07)	15.71 (11.01)
13 (25)	36.28 (6.27)	24.87 (3.94)	11.41 (4.87)
14 (16)	43.17 (9.47)	31.08 (7.46)	12.09 (5.32)
Age (n)	**Arm Fat Index (% of Fat)** *Mean (Standard Deviation)*	**Sitting Height Index (%)** *Mean (Standard Deviation)*	**Sum of Skinfold Thickness** *Mean (Standard Deviation)*
5 (7)	30.56 (4.16)	55.75 (1.49)	14.11 (1.89)
6 (22)	31.40 (6.20)	55.95 (1.07)	16.35 (6.29)
7 (32)	29.53 (6.80)	55.61 (1.05)	16.34 (8.74)
8 (44)	30.88 (7.70)	55.03 (1.20)	18.10 (7.91)
9 (37)	32.51 (8.50)	54.64 (1.06)	20.74 (11.53)
10 (40)	31.43 (8.02)	54.14 (1.06)	20.75 (8.95)
11 (45)	33.51 (7.37)	53.64 (1.35)	22.74 (8.13)
12 (40)	35.69 (9.92)	53.63 (1.13)	29.50 (17.10)
13 (25)	30.76 (8.28)	53.12 (0.78)	21.09 (7.52)
14 (16)	27.55 (8.85)	53.00 (1.11)	23.77 (10.22)

*Measurements highlighted in yellow are not normally distributed.

Table 4.12: Body Composition Measurements for Marshallese Females*

Age (n)	Total Upper Arm Area *Mean (Standard Deviation)*	Upper Arm Muscle Area *Mean (Standard Deviation)*	Upper Arm Fat Area *Mean (Standard Deviation)*
5 (6)	22.06 (0.83)	15.11 (0.54)	6.94 (0.37)
6 (15)	22.71 (2.50)	14.91 (1.54)	7.80 (1.89)
7 (27)	25.78 (8.23)	17.11 (6.16)	8.48 (2.41)
8 (39)	26.30 (6.44)	16.76 (2.45)	9.54 (4.64)
9 (38)	28.40 (6.74)	17.62 (3.70)	10.78 (3.73)
10 (40)	30.39 (6.60)	18.66 (2.49)	11.73 (4.91)
11 (34)	31.88 (7.19)	20.90 (4.43)	10.98 (4.01)
12 (35)	39.04 (10.70)	24.37 (4.45)	14.67 (7.24)
13 (20)	42.63 (10.35)	25.30 (2.84)	17.34 (8.28)
14 (8)	40.29 (7.86)	26.11 (4.11)	14.18 (4.62)
Age (n)	**Arm Fat Index (% of Fat)** *Mean (Standard Deviation)*	**Sitting Height Index (%)** *Mean (Standard Deviation)*	**Sum of Skinfold Thickness** *Mean (Standard Deviation)*
5 (6)	31.46 (0.89)	56.06 (1.31)	17.75 (2.51)
6 (15)	34.06 (5.85)	55.41 (1.41)	18.43 (4.12)
7 (27)	33.32 (4.76)	55.56 (1.30)	18.91 (3.87)
8 (39)	35.09 (7.12)	55.12 (0.96)	20.78 (7.51)
9 (38)	37.95 (7.57)	54.69 (1.19)	23.59 (6.78)
10 (40)	37.40 (7.11)	54.28 (1.19)	25.46 (9.85)
11 (34)	34.31 (8.62)	54.08 (1.08)	24.38 (8.64)
12 (35)	36.23 (7.21)	54.11 (1.22)	30.57 (11.98)
13 (20)	38.84 (8.36)	54.13 (1.35)	32.90 (12.16)
14 (8)	34.66 (5.63)	53.89 (0.88)	29.5 (8.37)

*Measurements highlighted in yellow are not normally distributed.

Table 4.13: Body Composition Z-scores for Marshallese Males Compared to NHANES (Frisancho 1990) Reference: Total Arm Area, Upper Arm Muscle Area, and Upper Arm Fat Area and Index

Age (n)	**Total Arm Area Z-Score**				**Upper Arm Muscle Area Z-Score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (7)	-0.75	0.38	-5.20	0.002*	-0.85	0.48	-4.75	0.003*	**5 (7)**
6 (22)	-0.55	0.70	-3.67	0.001*	-0.86	0.58	-7.02	< 0.001*	**6 (22)**
7 (32)	-0.82	0.66	-7.03	< 0.001*	-1.02	0.35	-16.65	< 0.001*	**7 (32)**
8 (44)	-0.55	0.63	-5.86	< 0.001*	-0.93	0.49	-12.46	< 0.001*	**8 (44)**
9 (37)	-0.47	0.96	-3.00	0.005*	-0.92	0.65	-8.60	< 0.001*	**9 (37)**
10 (40)	-0.68	0.61	-7.10	< 0.001*	-1.01	0.51	-12.58	< 0.001*	**10 (40)**
11 (45)	-0.68	0.51	-8.92	< 0.001*	-1.07	0.48	-14.91	< 0.001*	**11 (45)**
12 (40)	-0.37	1.04	-2.22	0.032*	-0.94	0.69	-8.71	< 0.001*	**12 (40)**
13 (25)	-0.98	0.45	-10.79	< 0.001*	-1.33	0.44	-15.14	< 0.001*	**13 (25)**
14 (16)	-0.79	0.60	-5.29	< 0.001*	-1.24	0.82	-6.07	< 0.001*	**14 (16)**
Age (n)	**Upper Arm Fat Area Z-score**				**Arm Fat Index Z-score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (7)	-0.31	0.33	-2.47	0.048*	0.24	0.57	1.12	0.306	**5 (7)**
6 (22)	-0.06	0.76	-0.34	0.737	0.49	0.78	2.95	0.008*	**6 (22)**
7 (32)	-0.22	0.85	-1.43	0.162	0.31	0.79	2.18	0.037*	**7 (32)**
8 (44)	-0.08	0.75	-0.66	0.512	0.39	0.90	2.91	0.006*	**8 (44)**
9 (37)	0.04	1.06	0.22	0.831	0.53	0.91	3.51	0.001*	**9 (37)**
10 (40)	-0.26	0.65	-2.56	0.015*	0.24	0.82	1.83	0.074	**10 (40)**
11 (45)	-0.23	0.51	-3.02	0.004*	0.33	0.66	3.37	0.002*	**11 (45)**
12 (40)	0.19	1.15	1.04	0.306	0.67	0.90	4.72	< 0.001*	**12 (40)**
13 (25)	-0.17	0.53	-1.64	0.115	0.56	0.77	3.66	0.001*	**13 (25)**
14 (16)	-0.12	0.52	-0.91	0.376	0.53	0.88	2.38	0.031*	**14 (16)**

*p < 0.05, statistically significant

Table 4.14: Body Composition Z-scores for Marshallese Females Compared to NHANES (Frisancho 1990) Reference: Arm Area, Upper Arm Muscle Area, and Upper Arm Fat Area and Index

Age (n)	Total Arm Area Z-Score				Upper Arm Muscle Area Z-Score				Age (n)
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (6)	-0.59	0.16	-9.32	< 0.001*	-0.51	0.17	-7.21	0.001*	**5 (6)**
6 (15)	-0.62	0.39	-6.18	< 0.001*	-0.79	0.40	-7.77	< 0.001*	**6 (15)**
7 (27)	-0.49	1.13	-2.24	0.034*	-0.55	1.54	-1.85	0.076	**7 (27)**
8 (39)	-0.66	0.69	-5.92	< 0.001*	-0.92	0.52	-11.08	< 0.001*	**8 (39)**
9 (38)	-0.74	0.66	-6.95	< 0.001*	-1.15	0.80	-8.80	< 0.001*	**9 (38)**
10 (40)	-0.70	0.58	-7.67	< 0.001*	-1.03	0.45	-14.29	< 0.001*	**10 (40)**
11 (34)	-0.82	0.49	-9.74	< 0.001*	-1.00	0.66	-8.82	< 0.001*	**11 (34)**
12 (35)	-0.55	0.77	-4.24	< 0.001*	-0.82	0.68	-7.08	< 0.001*	**12 (35)**
13 (20)	-0.52	0.65	-3.57	< 0.001*	-0.89	0.38	-10.41	< 0.001*	**13 (20)**
14 (8)	-0.87	0.49	-5.04	0.001*	-1.01	0.53	-5.36	0.001*	**14 (8)**
Age (n)	**Upper Arm Fat Area Z-score**				**Arm Fat Index Z-score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (6)	-0.46	0.11	-10.28	< 0.001*	-0.18	0.11	-3.94	0.011*	**5 (6)**
6 (15)	-0.23	0.49	-1.84	0.087	0.27	0.74	1.43	0.174	**6 (15)**
7 (27)	-0.29	0.54	-2.85	0.008*	0.07	0.57	0.68	0.502	**7 (27)**
8 (39)	-0.27	0.71	-2.37	0.023*	0.18	0.75	1.48	0.147	**8 (39)**
9 (38)	-0.32	0.51	-3.82	< 0.001*	0.33	0.76	2.65	0.012*	**9 (38)**
10 (40)	-0.31	0.64	-3.05	0.004*	0.24	0.70	2.13	0.039*	**10 (40)**
11 (34)	-0.55	0.41	-7.73	< 0.001*	-0.07	0.87	-0.47	0.644	**11 (34)**
12 (35)	-0.25	0.81	-1.83	0.077	0.18	0.79	1.34	0.189	**12 (35)**
13 (20)	-0.16	0.76	-0.95	0.353	0.34	0.82	1.84	0.081	**13 (20)**
14 (8)	-0.57	0.42	-3.81	0.007*	-0.12	0.57	-0.62	0.554	**14 (8)**

*p < 0.05, statistically significant

Table 4.15: Body Composition Z-scores for Marshallese Males Compared to NHANES (Frisancho 1990) Reference: Sitting Height, Elbow Breadth and Mid-Upper Arm Circumference

Age (n)	Sitting Height Z-Score				Sitting Height Index Z-score				Age (n)
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (7)	-0.90	0.66	-3.60	0.011*	0.20	0.83	0.63	0.56	**5 (7)**
6 (22)	-1.08	1.04	-4.89	< 0.001*	0.97	0.72	6.36	< 0.001*	**6 (22)**
7 (32)	-0.69	0.82	-4.80	< 0.001*	1.12	0.62	10.29	< 0.001*	**7 (32)**
8 (44)	-0.71	0.65	-7.28	< 0.001*	0.81	0.63	8.49	< 0.001*	**8 (44)**
9 (37)	-0.92	0.83	-6.76	< 0.001*	1.29	0.71	11.1	< 0.001*	**9 (37)**
10 (40)	-0.88	0.89	-6.27	< 0.001*	1.08	0.62	10.95	< 0.001*	**10 (40)**
11 (45)	-0.93	0.75	-8.24	< 0.001*	1.29	0.90	9.66	< 0.001*	**11 (45)**
12 (40)	-0.73	0.91	-5.06	< 0.001*	1.59	0.81	12.46	< 0.001*	**12 (40)**
13 (25)	-1.09	0.76	-7.15	< 0.001*	1.30	0.56	11.65	< 0.001*	**13 (25)**
14 (16)	-1.00	1.10	-3.65	0.02*	1.13	0.70	6.47	< 0.001*	**14 (16)**
Age (n)	**Elbow Breadth Z-Score**				**Mid Upper Arm Circumference Z-Score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (7)	-1.45	0.55	-7.04	< 0.001*	-0.80	0.44	-4.79	0.003*	**5 (7)**
6 (22)	-1.94	0.88	-10.33	< 0.001*	-0.60	0.75	-3.73	0.001*	**6 (22)**
7 (32)	-1.63	0.57	-16.04	< 0.001*	-0.88	0.69	-7.23	< 0.001*	**7 (32)**
8 (44)	-1.58	0.74	-14.26	< 0.001*	-0.58	0.69	-5.63	< 0.001*	**8 (44)**
9 (37)	-1.44	0.94	-9.27	< 0.001*	-0.52	0.93	-3.41	0.002*	**9 (37)**
10 (40)	-1.57	0.79	-12.53	< 0.001*	-0.74	0.70	-6.73	< 0.001*	**10 (40)**
11 (45)	-1.72	0.65	-17.67	< 0.001*	-0.74	0.61	-8.12	< 0.001*	**11 (45)**
12 (40)	-1.39	0.90	-9.72	< 0.001*	-0.44	1.09	-2.54	0.015*	**12 (40)**
13 (25)	-1.72	0.84	-10.24	< 0.001*	-1.07	0.55	-9.65	< 0.001*	**13 (25)**
14 (16)	-1.83	0.83	-8.81	< 0.001*	-0.87	0.72	-4.86	< 0.001*	**14 (16)**

*p < 0.05, statistically significant

Table 4.16: Body Composition Z-scores for Marshallese Females Compared to NHANES (Frisancho 1990) Reference: Sitting Height, Elbow Breadth and Mid-Upper Arm Circumference

Age (n)	**Sitting Height Z-Score**				**Sitting Height Index Z-score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (6)	-0.62	0.60	-2.52	0.053	0.56	0.69	1.97	0.106	**5 (6)**
6 (15)	-0.84	1.00	-3.23	0.06	0.65	0.70	3.60	0.003*	**6 (15)**
7 (27)	-0.70	0.79	-4.60	< 0.001*	1.16	0.81	7.44	< 0.001*	**7 (27)**
8 (39)	-1.02	1.02	-6.27	< 0.001*	1.20	0.60	12.52	< 0.001*	**8 (39)**
9 (38)	-0.66	0.71	-5.72	< 0.001*	1.04	0.56	11.39	< 0.001*	**9 (38)**
10 (40)	-1.05	0.94	-7.04	< 0.001*	1.68	0.92	11.53	< 0.001*	**10 (40)**
11 (34)	-0.61	0.94	-3.78	0.001*	1.56	0.77	11.83	< 0.001*	**11 (34)**
12 (35)	-0.87	0.75	-6.83	< 0.001*	1.38	0.76	10.70	< 0.001*	**12 (35)**
13 (20)	-0.93	0.72	-5.75	< 0.001*	1.42	0.90	7.08	< 0.001*	**13 (20)**
14 (8)	-1.44	1.55	-2.63	0.034*	1.06	0.58	5.13	0.001*	**14 (8)**
Age (n)	**Elbow Breadth Z-Score**				**Mid Upper Arm Circumference Z-Score**				**Age (n)**
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (6)	-1.50	0.81	-4.55	0.006*	-0.59	0.17	-8.26	< 0.001*	**5 (6)**
6 (15)	-1.53	0.70	-8.49	< 0.001*	-0.67	0.47	-5.56	< 0.001*	**6 (15)**
7 (27)	-1.72	0.67	-13.38	< 0.001*	-0.55	1.06	-2.72	0.011*	**7 (27)**
8 (39)	-1.73	0.94	-11.5	< 0.001*	-0.74	0.76	-6.08	< 0.001*	**8 (39)**
9 (38)	-1.60	0.73	-13.6	< 0.001*	-0.85	0.90	-5.84	< 0.001*	**9 (38)**
10 (40)	-1.83	0.89	-13.01	< 0.001*	-0.76	0.66	-7.33	< 0.001*	**10 (40)**
11 (34)	-1.65	0.97	-9.95	< 0.001*	-0.92	0.62	-8.63	< 0.001*	**11 (34)**
12 (35)	-1.72	0.84	-12.07	< 0.001*	-0.60	0.82	-4.30	< 0.001*	**12 (35)**
13 (20)	-1.61	0.67	-10.66	< 0.001*	-0.54	0.74	-3.30	0.004*	**13 (20)**
14 (8)	-1.70	1.11	-4.34	0.003*	-0.97	0.59	-4.62	0.002*	**14 (8)**

*p < 0.05, statistically significant

Table 4.17: Body Composition Z-scores for Marshallese Males Compared to NHANES (Frisancho 1990) Reference: Skinfolds

Age (n)	Triceps Skinfold Z-Score				Subscapular Skinfold Z-Score				Sum of Skinfold Thickness Z-Score				Age (n)
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (7)	-0.08	0.42	-0.52	0.62	0.11	0.32	0.91	0.399	-0.02	0.38	-0.13	0.901	**5 (7)**
6 (22)	0.15	0.78	0.89	0.38	0.42	1.07	1.85	0.079	0.31	0.94	1.53	0.141	**6 (22)**
7 (32)	-0.01	0.87	-0.04	0.97	0.5	1.64	1.73	0.093	0.22	1.27	0.99	0.328	**7 (32)**
8 (44)	0.10	0.85	0.81	0.42	0.54	1.17	3.03	0.004*	0.32	1.01	2.10	0.042*	**8 (44)**
9 (37)	0.23	1.03	1.37	0.18	0.53	1.38	2.34	0.025*	0.40	1.23	1.97	0.056	**9 (37)**
10 (40)	-0.08	0.74	-0.69	0.500	0.38	0.91	2.65	0.011*	0.16	0.84	1.16	0.251	**10 (40)**
11 (45)	-0.04	0.60	-0.44	0.661	0.2	0.59	2.26	0.029*	0.10	0.58	1.11	0.275	**11 (45)**
12 (40)	0.39	1.14	2.19	0.035*	0.81	1.38	3.71	0.001*	0.64	1.30	3.15	0.003*	**12 (40)**
13 (25)	0.09	0.66	0.70	0.488	0.10	0.52	0.92	0.366	0.10	0.57	0.86	0.399	**13 (25)**
14 (16)	0.12	0.70	0.70	0.493	0.55	0.90	2.43	0.028*	0.35	0.81	1.71	0.108	**14 (16)**

*$p < 0.05$, statistically significant

Table 4.18: Body Composition Z-scores for Marshallese Females Compared to NHANES (Frisancho 1990) Reference: Skinfolds

Age (n)	Triceps Skin Fold Z-Score				Subscapular Skin Fold Z-Score				Sum of Skin Fold Thickness Z-Score				Age (n)
	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	Mean	Standard Deviation	t	p	
5 (6)	-0.36	0.11	-8.24	< 0.001*	0.8	0.76	2.36	0.078	0.21	0.43	1.11	0.328	**5 (6)**
6 (15)	-0.06	0.61	-0.37	0.716	0.57	0.63	3.39	0.005*	0.27	0.63	1.57	0.14	**6 (15)**
7 (27)	-0.17	0.46	-1.90	0.069	0.49	0.69	3.71	0.001*	0.14	0.55	1.36	0.185	**7 (27)**
8 (39)	-0.12	0.75	-0.99	0.327	0.28	0.66	2.62	0.013*	0.07	0.70	0.64	0.524	**8 (39)**
9 (38)	-0.12	0.54	-1.40	0.169	0.29	0.60	3.02	0.005*	0.10	0.57	1.08	0.288	**9 (38)**
10 (40)	-0.11	0.72	-0.96	0.343	0.39	0.93	2.64	0.012*	0.15	0.81	1.20	0.239	**10 (40)**
11 (34)	-0.43	0.53	-4.71	< 0.001*	0.21	0.73	1.66	0.107	-0.08	0.64	-0.75	0.456	**11 (34)**
12 (35)	-0.10	0.84	-0.71	0.485	0.60	0.94	3.77	0.001*	0.30	0.90	1.96	0.058	**12 (35)**
13 (20)	0.02	0.86	0.09	0.931	0.52	0.77	3.04	0.007*	0.29	0.83	1.54	0.139	**13 (20)**
14 (8)	-0.45	0.48	-2.64	0.034*	0.38	0.66	1.52	0.180	-0.04	0.59	-0.19	0.856	**14 (8)**

*$p < 0.05$, statistically significant

Table 4.19: Body Composition Z-scores for Marshallese Males and Females Compared to NHANES (Frisancho 1990) Reference: Upper Arm Muscle Area by Height

Males					Females				
Age (n)	Mean	Standard Deviation	t	p	Age (n)	Mean	Standard Deviation	t	p
5 (7)	-0.33	0.49	-1.79	0.12	**5 (6)**	0.21	0.27	1.88	0.12
6 (22)	-0.07	0.64	-0.52	0.61	**6 (15)**	-0.2	0.56	-1.41	0.18
7 (32)	-0.36	0.50	-4.09	<0.001*	**7 (26)^**	-0.17	0.56	-1.58	0.13
8 (44)	-0.11	0.56	-1.32	0.20	**8 (39)**	-0.15	0.53	-1.75	0.09
9 (37)	0.00	0.71	-0.03	0.98	**9 (37)^**	-0.21	0.65	-1.96	0.06
10 (40)	-0.09	0.62	-0.91	0.37	**10 (40)**	-0.18	0.66	-1.70	0.10
11 (45)	-0.15	0.77	-1.33	0.19	**11 (13)^**	-0.16	0.69	-0.86	0.41
12 (20)^	0.09	0.99	0.41	0.69	**12 (21)^**	0.35	0.92	1.75	0.10
13 (17)^	-0.38	0.64	-2.42	0.03*	**13 (18)^**	0.04	0.59	0.28	0.78
14 (14)^	0.11	0.94	0.42	0.68	**14 (6)^**	0.18	0.49	0.87	0.43

*p < 0.05, statistically significant

^These age and sex categories have children excluded due to heights less than what Frisancho (1990) presents.

Table 4.20: WHO 2007 Growth Reference Height for Age Z-score: 2006 Pilot Study Data vs. 2008 Nutritional Assessment

Age Group	9				10				11			
Sex	Males		Females		Males		Females		Males		Females	
Year	2006	2008-2009	2006	2008-2009	2006	2008-2009	2006	2008-2009	2006	2008-2009	2006	2008-2009
n	4	37	3	38	20	40	47	40	39	45	41	34
Mean	-1.36	-1.56	-0.46	-1.55	-1.2	-1.51	-1.1	-1.89	-1.53	-1.62	-1.98	-1.64
Standard Deviation	0.97	0.92	0.73	0.68	0.86	0.86	1.27	1.00	0.92	0.68	1.19	1.08
t	0.42		2.67		1.32		3.20		0.48		-1.32	
p	0.674		0.011*		0.194		0.002*		0.633		0.192	

Age Group	12				13			
Sex	Males		Females		Males		Females	
Year	2006	2008-2009	2006	2008-2009	2006	2008-2009	2006	2008-2009
n	20	40	16	35	9	25	4	20
Mean	-2.23	-1.76	-2.42	-1.79	-2.69	-2.07	-2.4	-1.73
Standard Deviation	0.74	0.86	1.01	0.82	0.98	1.17	0.85	0.75
t	-2.10		-2.35		-1.412		-1.60	
p	0.04*		0.023*		0.168		0.123	

*$p < 0.05$, statistically significant

Table 4.21: WHO 2007 Growth Reference Weight for Age Z-score: 2006 Pilot Study Data vs. 2008 Nutritional Assessment

Age Group	9			
Sex	Males		Females	
Year	2006	2008-2009	2006	2008-2009
n	4	37	3	38
Mean	-0.02	-0.84	0.06	-0.91
Standard Deviation	2.07	1.20	0.83	0.85
t	1.21		1.91	
p	0.236		0.064	

*p < 0.05, statistically significant

Table 4.22: WHO 2007 Growth Reference Body Mass Index for Age Z-score: 2006 Pilot Study Data vs. 2008 Nutritional Assessment

Age Group	**9**				**10**				**11**			
Sex	**Males**		**Females**		**Males**		**Females**		**Males**		**Females**	
Year	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**
n	4	37	3	38	20	40	47	40	39	45	41	34
Mean	1.02	0.19	0.43	-0.01	0.17	-0.08	0.01	-0.13	0.02	-0.04	-0.38	-0.25
Standard Deviation	1.99	1.01	0.58	0.76	1.14	0.98	1.16	0.93	1.13	1.02	1.09	0.89
t	1.41		0.97		0.87		0.64		0.26		-0.51	
p	0.166		0.338		0.386		0.527		0.794		0.609	

Age Group	**12**				**13**			
Sex	**Males**		**Females**		**Males**		**Females**	
Year	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**	**2006**	**2008-2009**
n	20	40	16	35	9	24	4	20
Mean	-0.52	0.22	-0.38	0.21	-0.51	-0.44	-1.35	0.07
Standard Deviation	1.1	1.21	0.91	0.90	0.88	0.88	0.81	0.98
t	-2.31		-2.18		-0.20		-2.71	
p	0.025*		0.034*		0.842		0.013*	

*$p < 0.05$, statistically significant

Table 4.23: Rates of Malnutrition from Previous and Current Nutritional Assessments Conducted in the Marshall Islands

Source	Year	n	Age	Malnutrition Rate	
Majuro Hospital Internal Records	1987-1989		0-5 years	10.0%	**Underweight (moderate to severe)**
			6-14 years	35.0%	**Underweight**
				8.0%	**Overweight**
National Nutritional Survey	1991	629 (Total) 239 (Majuro)	0-6 years	20.0%	**Underweight (moderate to severe)**
				36.0%	**Underweight (mild)**
				36.0%	**Normal Weight**
				8.0%	**Overweight**
				24.0%	**Stunted**
				3.0%	**Wasted**
			7-14 years	40.0%	**Underweight (moderate to severe)**
				35.0%	**Stunted**
Gittelsohn	1998	129	0-5 years	39.6%	**Stunted**
				7.0%	**Wasted**
		467	7-17.9 years See Tables II-VII	40.0%	**Underweight (moderate to severe)**
				35.0%	**Stunted**
				2.0%	**Wasted**
Gammino	2001	150	0-5 years	22.6%	**Underweight (moderate to severe)**
				39.3%	**Stunted**
				1.3%	**Wasted**
Hughes et al.	2004	99 (Rita)	5-12 years	8.1%	**Underweight**
				25.3%	**Stunted**
		173 (Laura)	5-12 years	16.3%	**Underweight**
				32.5%	**Stunted**
Foster	2008-2009	570 (Majuro)	5-14 years	8.2%	**Underweight**
				0.5%	**Underweight or Thinness**
				87.4%	**Normal Weight**
				9.5%	**Overnutrition**
				2.6%	**Obesity**
				34.6%	**Stunted**

Table 4.24: Undernutrition (%) by Age and Sex: Gittelsohn (NHANES II) vs. Foster (WHO 2007)

Age Group	Stunting (Height/Age < -2SD)				Wasting (Wt/Ht<-2SD)				Low Weight for Age (Weight/Age <-2SD)			
	Gittelsohn		Foster		Gittelsohn		Foster		Gittelsohn		Foster	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4.9	32.1	39.6			5.8	7.0	N/A	N/A	21.4	33.3		
5-9.9	28.8	35.2	27.5	30.6	1.8	0.0	N/A	N/A	13.4	12.0	10.6	5.6
10-17.9	48.7	41.7	34.3	46.0	0.0	0.0	N/A	N/A	24.4	14.0		

Table 4.25: Overnutrition (%) by Age and Sex: Gittelsohn (NHANES II) vs. Foster (WHO 2007)

Age Group	Overweight (25-30)				Obese (>30)			
	Gittelsohn		Foster		Gittelsohn		Foster	
	Male	Female	Male	Female	Male	Female	Male	Female
0-4.9	1.4	0			1.4	1.7		
5-9.9	0	0	6.3	7.3	0.9	1.1	4.2	0.8
10-17.9	0.8	5.6	15.1	8.0	0	1.4	2.4	2.9

Table 4.26: Height of Australian Aborigine and Pacific Island Children (cm): Males

Country	People or Place	Authors		Age (yr)									
				5	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**107.1**	**110.4**	**116.8**	**121.6**	**125.7**	**130.7**	**134.6**	**139.8**	**143.4**	**152.2**
			SD	2.9	5.3	5.3	5.0	5.8	5.8	5.1	6.8	8.1	8.5
Australia	Aborigines	Hitchcock et al. 1987	**Mean**	**106.0**	**112.0**	**118.0**	**123.0**	**129.0**	**134.0**	**140.0**	**145.0**	**151.0**	**156.0**
Hawaii	Samoans	Bindon & Zansky 1986	**Mean**		**116.3**	**123.2**	**129.8**	**136.2**	**138.5**	**143.6**			
			SD		7.2	6.0	5.0	6.7	6.3	6.3			
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**	**105.0**	**110.0**	**118.6**	**121.0**				**140.8**		
	Bundi	Zemel & Jenkins 1989	**Mean**	**94.3**	**97.0**	**106.2**	**110.1**	**110.6**	**118.4**	**123.6**	**123.0**	**127.1**	**133.4**
			SD	16.6	6.0	5.5	5.2	4.4	4.8	5.0	4.1	7.1	5.9
	Manus	Schall, unpubl.	**Mean**	**103.8**	**109.0**	**112.3**		**123.6**	**126.2**		**132.9**	**141.9**	**144.9**
			SD	5.6	6.4	6.4	1.3	7.3	7.2	7.4	4.6	7.4	8.5
	Mountain OK	J. Schwartz & R.C. Brumbraugh, unpubl.	**Mean**	**105.4**	**103.3**	**114.5**	**114.2**		**126.8**		**141.2**		**146.3**
			SD	19.5	6.4	15.6	8.5	12.1	10.3	7.7	8.1	14.4	8.5
Samoa, American	Samoans	Bindon & Zansky 1986	**Mean**		**116.9**	**121.2**	**127.3**	**131.9**	**139.0**	**143.6**			
			SD		4.1	4.8	4.9	6.0	7.3	5.8			
	Samoans	Bindon & Zansky 1986	**Mean**		**115.0**	**115.8**	**119.5**	**126.9**	**131.5**	**134.5**			
			SD		4.7	6.4	5.6	4.5	5.1	5.8			

	Apia	Wigg 1978	**Mean**	**108.0**									
Solomon Islands	Aita	Friedlander 1987	**Mean**	**95.0**	**102.0**	**107.0**	**115.0**		**122.0**	**122.0**	**126.0**	**135.0**	
	Lau	Friedlander 1987	**Mean**	**105.0**	**115.0**	**116.0**	**123.0**	**126.0**	**135.0**	**134.0**		**148.0**	**143.0**
	Ontong Java	Friedlander 1987	**Mean**	**107.0**	**115.0**		**125.0**		**134.0**		**142.0**	**150.0**	

Table 4.27: Height of Australian Aborigine and Pacific Island Children (cm): Females

Country	People or Place	Authors		Age (yr) 5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**106.6**	**110.7**	**116.3**	**119.3**	**125.8**	**128.7**	**137.2**	**141.5**	**146.3**	**146.5**
			SD	3.5	5.8	5.4	6.3	5.0	7.2	7.7	5.8	5.2	11.3
Australia	Aborigines	Hitchcock et al. 1987	**Mean**	**104.0**	**112.0**	**118.0**	**124.0**	**130.0**	**136.0**	**142.0**	**148.0**	**151.0**	**154.0**
Fiji	Suva	Clegg 1989	**Mean**			**120.5**	**127.0**	**130.0**	**138.0**	**144.5**	**148.0**	**155.0**	**161.0**
Hawaii	Samoans	Bindon & Zansky 1986	**Mean**		**117.3**	**123.7**	**129.7**	**134.3**	**140.8**	**145.6**			
			SD		4.7	3.9	6.3	5.1	5.3	6.4			
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**	**105.0**	**110.0**	**115.0**	**120.0**				**135.6**		
			SD			8.9					9.6		
	Bundi	Zemel & Jenkins 1989	**Mean**	**96.2**	**99.2**	**105.4**	**109.0**	**114.9**	**118.1**	**121.5**	**123.0**	**126.4**	**134.1**
			SD	4.8	6.2	4.5	4.1	5.3	3.8	5.3	4.6	7.5	7.2
	Manus	Schall, unpubl.	**Mean**	**96.3**	**111.7**	**114.9**	**123.0**	**123.0**	**129.6**	**137.5**	**142.5**	**146.9**	**146.4**
			SD	7.1	4.7	6.6	5.0	5.6	7.2	7.2	8.6	8.4	9.3
	Mountain OK	J. Schwartz & R.C. Brumbraugh, unpubl.	**Mean**		**106.2**	**117.0**	**109.2**		**127.1**		**138.1**	**126.9**	**137.0**
			SD		12.4	11.3	5.8		6.6		9.6	5.5	17.9
Samoa, American	Samoans	Bindon & Zansky 1986	**Mean**		**116.0**	**120.6**	**127.8**	**133.6**	**137.5**	**145.3**			
			SD		5.4	4.9	6.4	4.9	9.4	7.7			

	Samoans	Bindon & Zansky 1986	**Mean**		**111.6**	**115.9**	**122.8**	**128.4**	**131.5**	**137.3**			
			SD		5.1	4.5	9.5	6.2	3.9	6.4			
	Apia	Wigg 1978	**Mean**	**104.0**									
Solomon Islands	Aita	Friedlander 1987	**Mean**	**98.0**	**104.0**	**106.0**	**115.0**				**132.0**		
	Lau	Friedlander 1987	**Mean**	**103.0**	**108.0**	**119.0**	**121.0**	**128.0**	**134.0**				
	Ontong Java	Friedlander 1987	**Mean**	**110.0**	**115.0**	**120.0**	**126.0**	**130.0**	**136.0**	**143.0**			**146.0**

Table 4.28: Weight of Australian Aborigine and Pacific Island Children (cm): Males

Boys Country	People or Place	Authors		Age (yr)									
				5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**17.8**	**19.3**	**21.3**	**24.2**	**27.0**	**28.9**	**31.7**	**37.8**	**36.9**	**44.9**
			SD	1.1	3.1	3.1	4.1	6.3	5.2	5.0	10.3	6.7	8.0
Australia	Aborigines	Hitchcock et al. 1987	**Mean**	**17.0**	**19.0**	**21.0**	**22.5**	**25.0**	**27.5**	**31.0**	**35.0**	**39.0**	**44.5**
Hawaii	Samoans	Bindon & Zansky 1986	**Mean**		**23.3**	**25.4**	**30.0**	**35.9**	**38.4**	**43.7**			
			SD		3.0	3.1	5.4	8.2	12.1	12.5			
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**	**20.0**	**21.0**	**22.4**	**24.0**				**35.4**		
			SD			3.9					5.8		
	Bundi	Zemel & Jenkins 1989	**Mean**	**14.8**	**15.2**	**18.3**	**20.2**	**20.4**	**24.0**	**24.5**	**25.6**	**27.2**	**31.4**
			SD	1.7	2.0	2.0	2.6	2.2	2.3	3.7	2.1	4.9	4.9
	Manus	Schall, unpubl.	**Mean**	**15.5**	**17.3**	**18.2**		**22.4**	**24.3**		**26.0**	**32.7**	**35.4**
	Mountain OK	J. Schwartz & R.C. Brumbraugh, unpubl.	**Mean**	**18.4**	**16.8**	**21.2**	**20.8**				**36.4**		
			SD	8.0	3.2	7.3	4.1	4.3	3.1	3.9	6.9	6.7	7.6
Samoa, American	Samoans	Bindon & Zansky 1986	**Mean**		**22.6**	**24.7**	**27.4**	**31.6**	**33.8**	**37.1**			
			SD		4.2	3.4	3.6	5.2	5.8	4.3			
	Samoans	Bindon & Zansky 1986	**Mean**		**19.8**	**22.1**	**23.6**	**28.5**	**29.3**	**32.2**			
			SD		2.5	2.6	3.2	6.9	3.2	4.7			
Solomon Islands	Aita	Friedlander 1987	**Mean**	**15.0**	**17.5**	**19.0**	**22.0**	**24.0**	**27.5**	**27.0**	**30.5**	**34.4**	
	Lau	Friedlander 1987	**Mean**	**17.5**	**21.0**	**22.0**	**25.0**	**27.5**	**30.0**	**30.5**	**39.0**	**43.0**	

Table 4.29: Weight of Australian Aborigine and Pacific Island Children (cm): Females

Girls Country	People or Place	Authors		Age (yr) 5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**17.3**	**19.2**	**21.1**	**23.0**	**26.2**	**28.1**	**32.9**	**39.0**	**42.6**	**42.3**
			SD	1.4	2.3	2.5	4.7	3.9	5.3	6.5	8.1	8.0	10.9
Australia	Aborigines	Hitchcock et al. 1987	**Mean**	**16.0**	**18.0**	**21.0**	**24.0**	**26.0**	**29.5**	**32.5**	**37.5**	**44.0**	**46.5**
Fiji	Suva	Clegg 1989	**Mean**			**24.0**	**26.2**	**28.0**	**32.3**	**36.5**	**40.8**	**47.8**	**54.0**
Hawaii	Samoans	Bindon & Zansky 1986	**Mean**		**23.4**	**26.8**	**30.8**	**35.0**	**41.6**	**46.0**			
			SD		3.7	3.3	6.3	6.2	8.6	12.1			
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**	**19.0**	**19.9**	**20.9**	**22.0**				**32.6**		
			SD			3.2					7.6		
	Bundi	Zemel & Jenkins 1989	**Mean**	**14.6**	**15.9**	**18.0**	**18.3**	**20.6**	**24.5**	**24.1**	**26.8**	**27.0**	**31.8**
			SD	1.8	2.5	1.7	2.3	2.7	2.9	2.6	2.9	4.4	7.2
	Manus	Schall, unpubl.	**Mean**	**12.7**	**17.2**	**19.4**	**21.6**	**21.8**	**25.5**	**30.0**	**35.0**	**38.1**	**38.3**
	Mountain OK	J. Schwartz & R.C. Brumbraugh, unpubl.	**Mean**		**18.1**	**22.4**	**17.9**		**26.5**		**34.4**	**27.3**	**36.0**
			SD	2.8	4.2	6.6	3.3		4.1		9.1	4.9	9.7
Samoa, American	Samoans	Bindon & Zansky 1986	**Mean**		**21.5**	**24.8**	**28.1**	**32.3**	**34.4**	**41.6**			
			SD		3.0	6.0	5.3	4.1	5.3	9.1			
	Samoans	Bindon & Zansky 1986	**Mean**		**19.2**	**24.3**	**25.6**	**27.2**	**28.4**	**33.8**			
			SD		2.0	9.1	4.8	3.8	2.7	6.6			

Table 4.30: Mean Sitting Height of Australian Aborigine and Pacific Island Children (cm): Males and Females

Boys Country	People or Place	Authors		Age (yr) 5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**59.7**	**61.8**	**64.9**	**66.9**	**68.7**	**70.7**	**72.2**	**75.0**	**76.2**	**80.7**
			SD	1.9	3.1	2.7	2.2	2.7	3.0	2.9	4.0	3.9	5.3
Australia	Aborigine B	Abbie 1967	**Mean**	**55.8**	**57.8**	**61.5**	**63.2**	**63.7**		**65.4**	**70.9**	**76.8**	
Papua New Guinea	Bundi	Malcolm 1971	**Mean**	**53.4**	**55.1**	**56.2**	**57.9**	**60.2**	**61.4**	**63.6**	**63.0**	**65.5**	**65.5**
	Mt Hagen	Harvey 1973	**Mean**		**60.1**	**62.0**	**63.2**	**64.9**	**66.8**	**68.6**	**70.0**	**71.2**	**72.9**
	Karkar Is.	Harvey 1973	**Mean**	**56.1**	**58.0**	**60.3**	**61.4**	**62.4**	**64.7**	**66.9**	**67.7**	**68.5**	**70.2**
New Zealand	Maori	N.Z. Dept Health 1971	**Mean**		**63.0**	**66.0**	**68.7**	**70.7**	**73.0**	**75.2**	**77.3**	**80.5**	**84.0**
Girls Country	**People or Place**	**Authors**		**Age (yr) 5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**59.7**	**61.3**	**64.3**	**65.7**	**68.8**	**69.8**	**74.2**	**76.5**	**79.2**	**78.9**
			SD	1.8	3.2	2.5	3.3	2.6	3.5	4.0	3.2	2.6	5.6
Australia	Aborigine B	Abbie 1967	**Mean**	**56.6**	**59.7**			**63.6**			**68.5**		
Papua New Guinea	Bundi	Malcolm 1971	**Mean**	**52.4**	**54.3**	**56.7**	**59.1**	**60.6**	**61.2**	**63.1**	**63.4**	**66.0**	**68.6**
	Mt Hagen	Harvey 1973	**Mean**		**60.1**	**63.2**	**64.2**	**65.5**	**67.5**	**69.1**	**71.4**	**72.1**	**76.0**
	Karkar Is.	Harvey 1973	**Mean**	**55.3**	**57.3**	**59.3**	**61.3**	**62.9**	**63.8**	**66.0**	**68.8**	**70.3**	**72.6**

New Zealand	Maori	N.Z. Dept Health 1971	**Mean**		**62.5**	**65.2**	**68.0**	**70.5**	**73.0**	**76.0**	**80.0**	**83.0**	**85.0**

Table 4.31: Upper Arm Circumference of Pacific Island Children (cm): Males and Females

Boys Country	People or Place	Authors		Age (yr) 5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**16.3**	**17.1**	**17.2**	**18.3**	**19.3**	**19.6**	**20.3**	**22.3**	**21.3**	**23.2**
			SD	0.8	1.6	1.5	1.6	2.5	2.1	2.1	3.8	1.8	2.5
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**			**16.3**					**19.7**		
	Bundi	B Zemel & C. Jenkins, Unpubl.	**Mean**	**15.2**	**14.7**	**15.8**	**16.2**	**16.2**	**17.2**	**17.4**	**17.4**	**18.0**	**18.5**
			SD	1.0	1.5	0.7	1.1	1.1	0.8	1.5	0.8	1.5	1.0
	Manus	J. Schall, unpubl.	**Mean**					**16.6**	**17.4**		**17.6**	**19.4**	**20.0**
			SD					1.3	1.1		1.0	2.1	1.6
Girls Country	**People or Place**	**Authors**		**Age (yr) 5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**16.6**	**16.9**	**17.8**	**18.1**	**18.7**	**19.4**	**19.9**	**22.0**	**23.0**	**22.4**
			SD	0.3	0.9	2.3	2.0	2.5	2.0	2.2	2.8	2.7	2.1
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**			**15.9**					**18.8**		
	Bundi		**Mean**	**15.1**	**15.5**	**15.8**	**15.8**	**16.7**	**17.7**	**17.6**	**18.4**	**18.4**	**19.4**
			SD	0.9	1.1	1.0	1.0	1.1	1.2	0.9	1.4	1.2	1.9
	Manus		**Mean**			**16.9**	**17.0**	**17.0**	**18.0**	**19.1**	**20.8**	**20.8**	**20.9**
			SD			1.5	1.3	1.1	1.3	1.4	1.8	1.8	1.8

Table 4.32: Triceps Skinfolds of Pacific Island Children (mm): Males and Females

Boys Country	People or Place	Authors		Age (yr) 5	6	7	8	9	10	11	12	13	14
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**8.6**	**9.5**	**9.0**	**10.1**	**11.4**	**11.0**	**12.2**	**14.9**	**11.6**	**11.2**
			SD	1.3	3.0	3.5	3.7	5.3	4.2	4.2	7.7	4.4	4.6
Papua New Guinea	Wopkaiman	Lourie et al. 1986	**Mean**		**4.7**		**4.3**		**4.3**		**4.8**		**4.9**
	Bundi	B Zemel & C. Jenkins, Unpubl.	**Median**	**9.0**				**7.5**	**9.0**		**7.0**	**8.0**	**8.0**
	Manus	J. Schall, unpubl.	**Median**					**4.8**	**4.8**		**4.7**	**5.0**	**5.2**
Tokelau Islands	Tokelauans	Ramirez & Mueller 1980	**Mean**	**9.5**		**7.8**		**8.0**		**9.1**		**8.8**	
New Zealand	Tokelauans	Ramirez & Mueller 1980	**Mean**	**9.0**		**8.5**		**9.6**		**10.6**		**10.5**	
Girls Country	**People or Place**	**Authors**		**Age (yr) 5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**9.1**	**10.2**	**10.4**	**11.5**	**12.7**	**13.2**	**12.1**	**14.5**	**16.5**	**13.8**
			SD	0.4	2.3	1.9	4.1	3.2	4.4	3.6	5.3	6.3	3.5
Papua New	Wopkaiman	Lourie et al. 1986	**Mean**		**5.0**		**5.0**		**5.1**		**5.5**		**6.0**

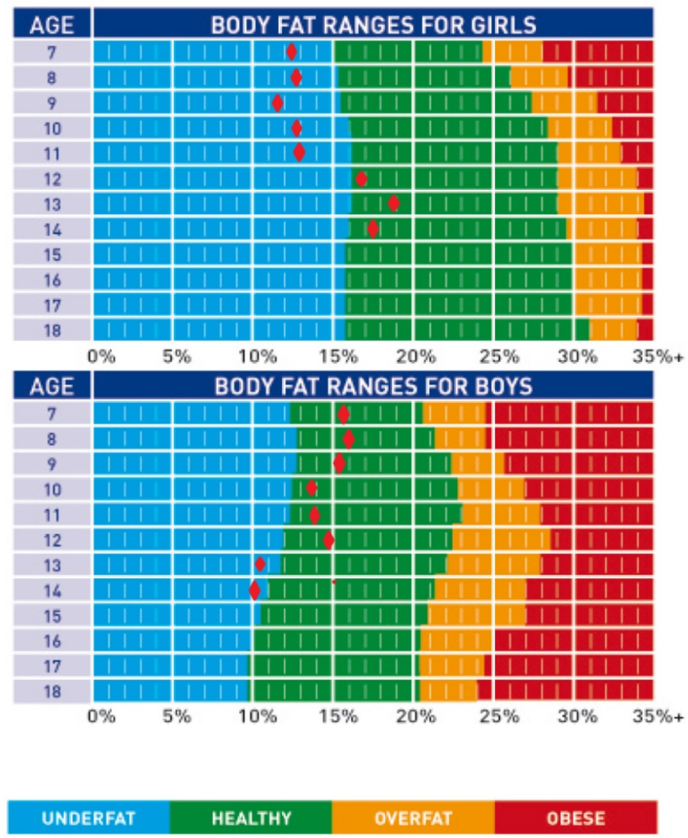
Guinea	Bundi	B Zemel & C. Jenkins, Unpubl.	**Mean**	**9.0**		**9.0**	**8.0**	**9.0**	**10.0**	**9.0**	**11.0**	**10.0**	**10.0**
	Manus	J. Schall, unpubl.	**Median**			**6.5**	**5.8**	**6.0**	**6.0**	**6.6**	**7.5**	**7.6**	**6.2**
Tokelau Islands	Tokelauans	Ramirez & Mueller 1980	**Mean**	**9.2**		**9.7**		**9.8**		**11.9**		**13.1**	
New Zealand	Tokelauans	Ramirez & Mueller 1980	**Mean**	**10.0**		**11.0**		**12.2**		**15.0**		**17.0**	

Table 4.33: Subscapular Skinfolds of Pacific Island Children (mm): Males and Females

Boys **Country**	**People or Place**	**Authors**		**Age (yr)** **5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**5.5**	**6.9**	**7.4**	**8.0**	**9.4**	**9.7**	**10.5**	**14.6**	**9.5**	**12.6**
			SD	0.8	3.5	5.4	4.5	6.7	5.0	4.5	9.8	3.6	5.9
Papua New Guinea	Bundi	B Zemel & C. Jenkins, Unpubl.	**Median**	**6.0**				**5.0**	**6.0**		**6.0**	**6.0**	**7.0**
	Manus	J. Schall, unpubl.	**Median**					**4.7**	**5.1**		**4.5**	**5.4**	**4.8**
Tokelau Islands	Tokelauans	Ramirez & Mueller 1980	**Mean**	**6.3**		**5.9**		**6.5**		**7.1**		**7.4**	
New Zealand	Tokelauans	Ramirez & Mueller 1980	**Mean**	**6.5**		**6.4**		**7.6**		**9.9**		**10.0**	
Girls **Country**	**People or Place**	**Authors**		**Age (yr)** **5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**
Republic of the Marshall Islands	Marshallese	Foster 2015	**Mean**	**8.7**	**8.2**	**8.4**	**9.4**	**10.9**	**12.2**	**12.3**	**16.1**	**16.4**	**15.9**
			SD	2.0	2.1	2.4	3.8	3.9	6.1	5.5	7.2	6.0	5.1
Papua New Guinea	Bundi	B Zemel & C. Jenkins, Unpubl.	**Median**	**6.0**		**7.0**	**7.0**	**6.0**	**9.0**	**8.0**	**10.0**	**9.0**	**8.0**
	Manus	J. Schall, unpubl.	**Median**			**5.9**	**5.7**	**5.5**	**6.5**	**6.5**	**8.9**	**8.3**	**8.6**

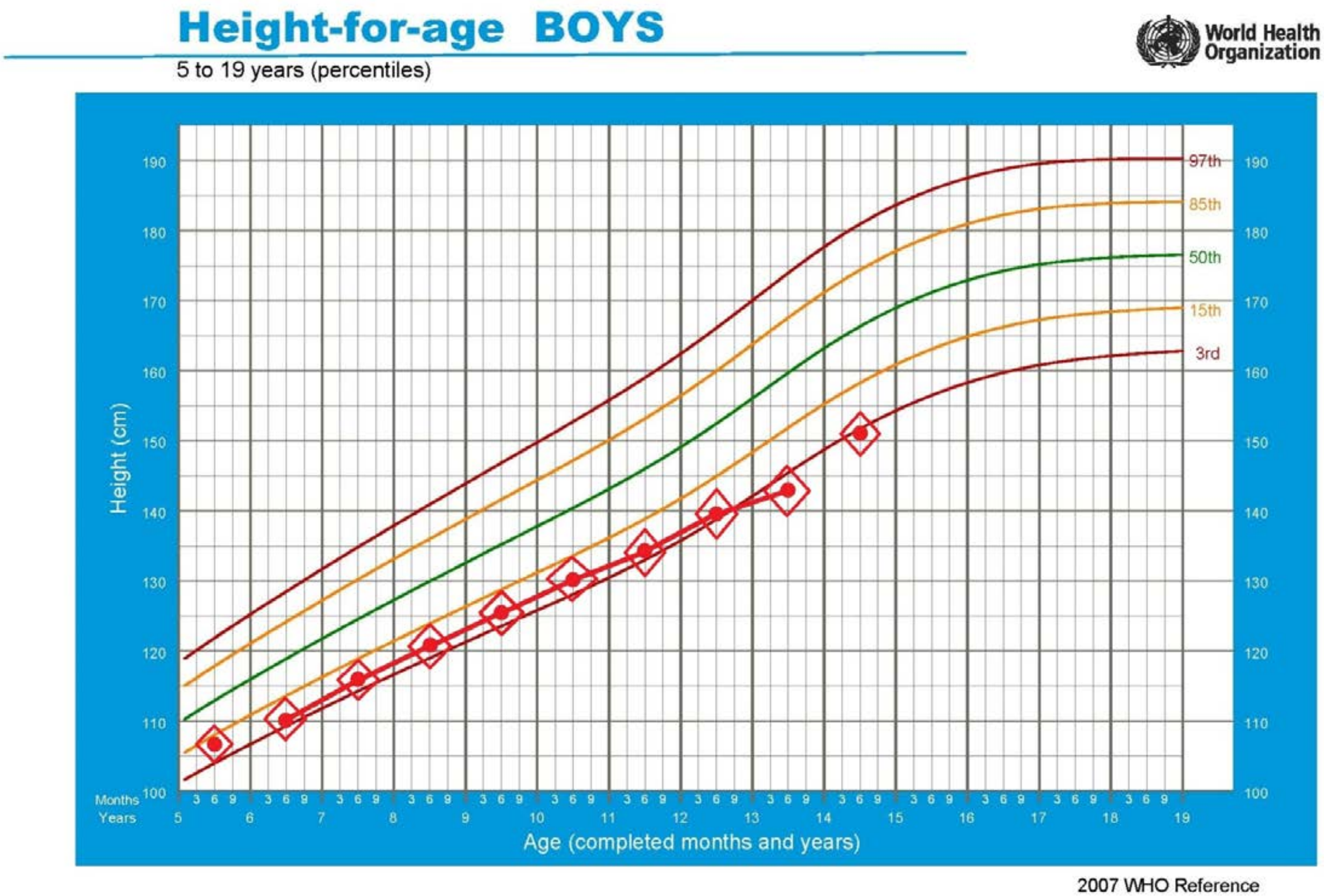
Tokelau Islands	Tokelauans	Ramirez & Mueller 1980	**Mean**	**7.2**	**7.1**	**7.4**	**10.0**	**11.8**
New Zealand	Tokelauans	Ramirez & Mueller 1980	**Mean**	**8.4**	**9.7**	**11.5**	**15.8**	**17.7**

Figure 4.1: Body Fat Ranges for Girls and Boys*



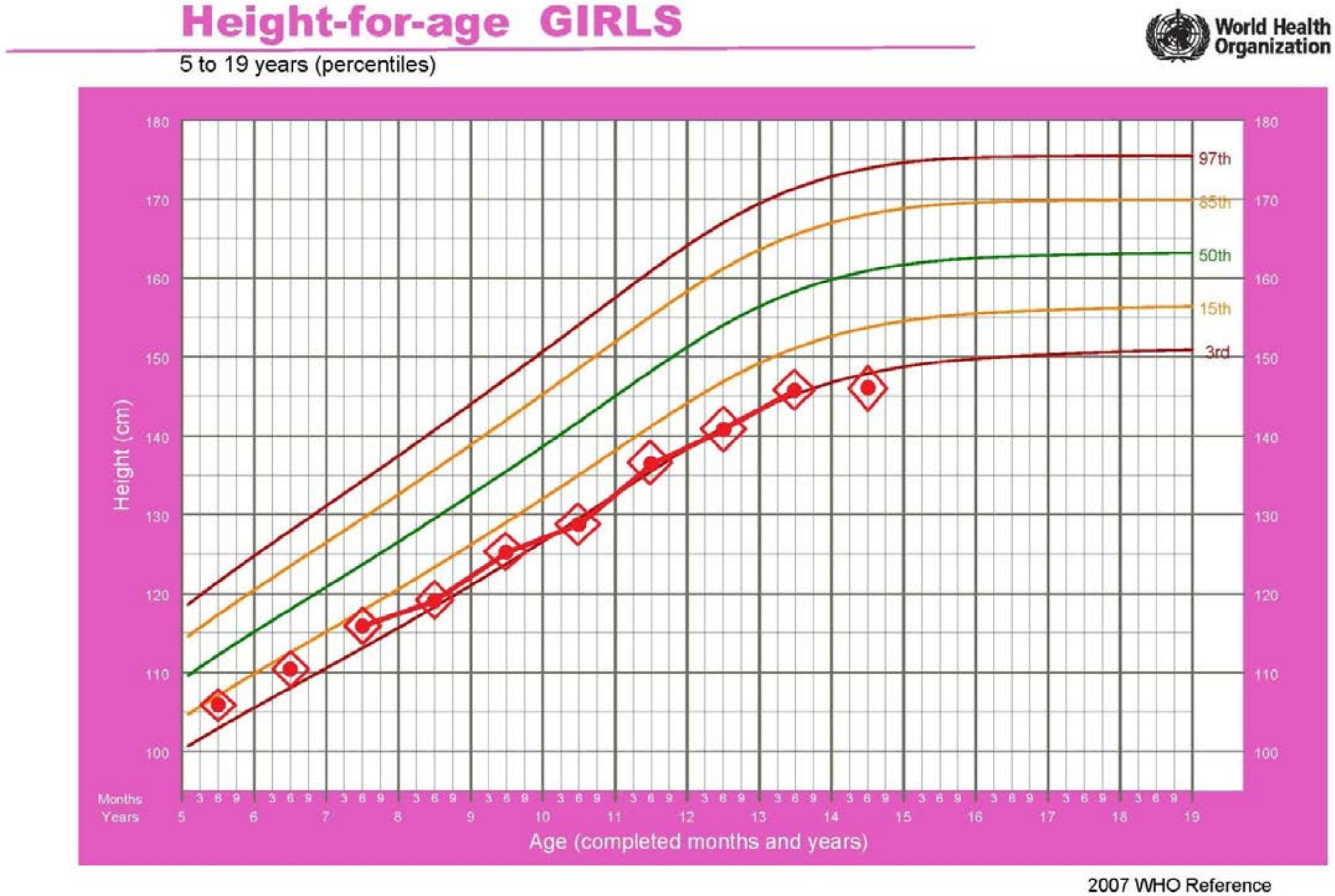
***Red diamonds represent the average body fat % for each Marshallese sex/age group**

Figure 4.2: Marshallese boys compared to the WHO 2007 Height-for-age reference*



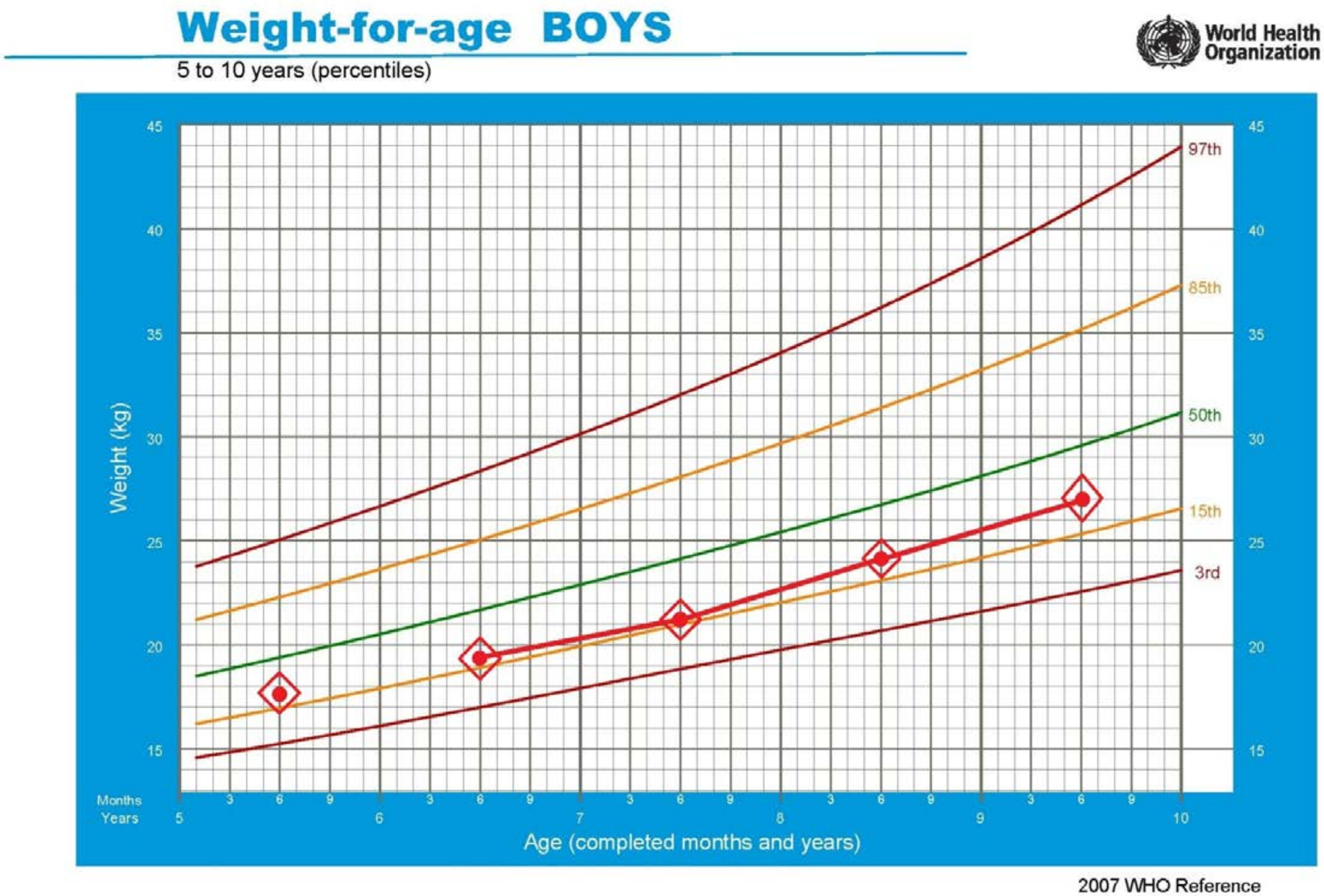
***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

Figure 4.3: Marshallese girls compared to the WHO 2007 Height-for-age reference



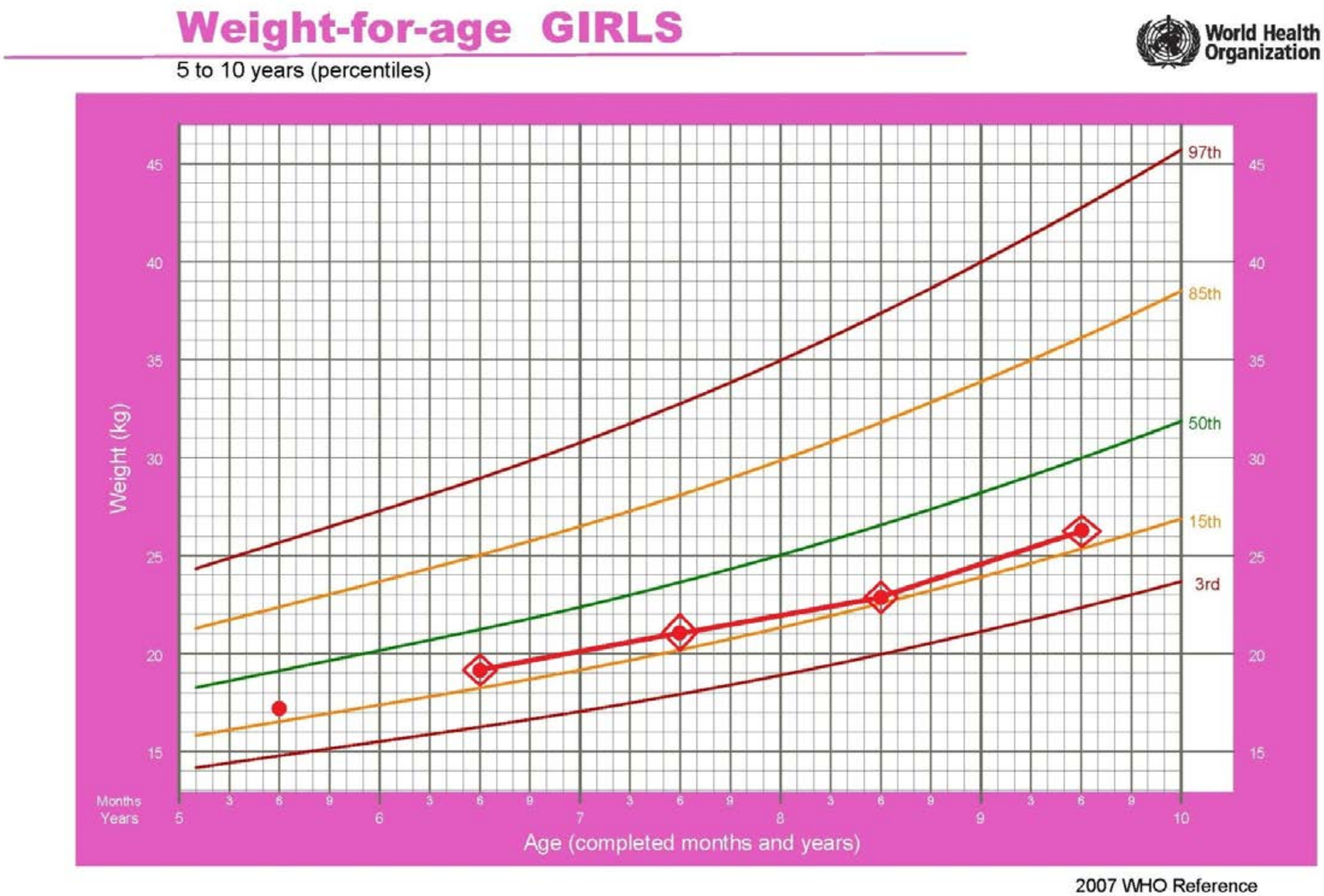
***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

Figure 4.4: Marshallese boys compared to the WHO 2007 Weight-for-age reference



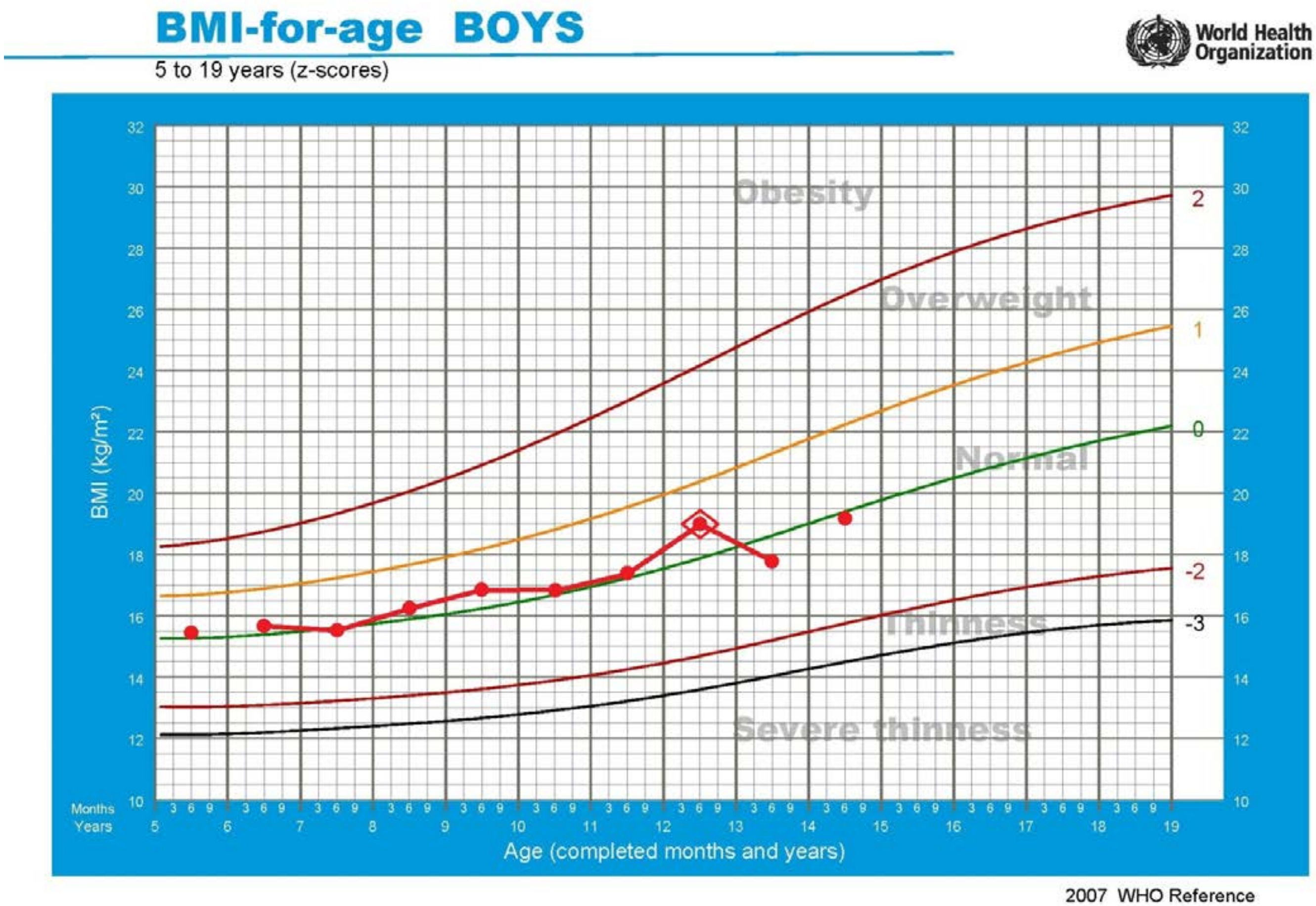
***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

Figure 4.5: Marshallese girls compared to the WHO 2007 Weight-for-age reference



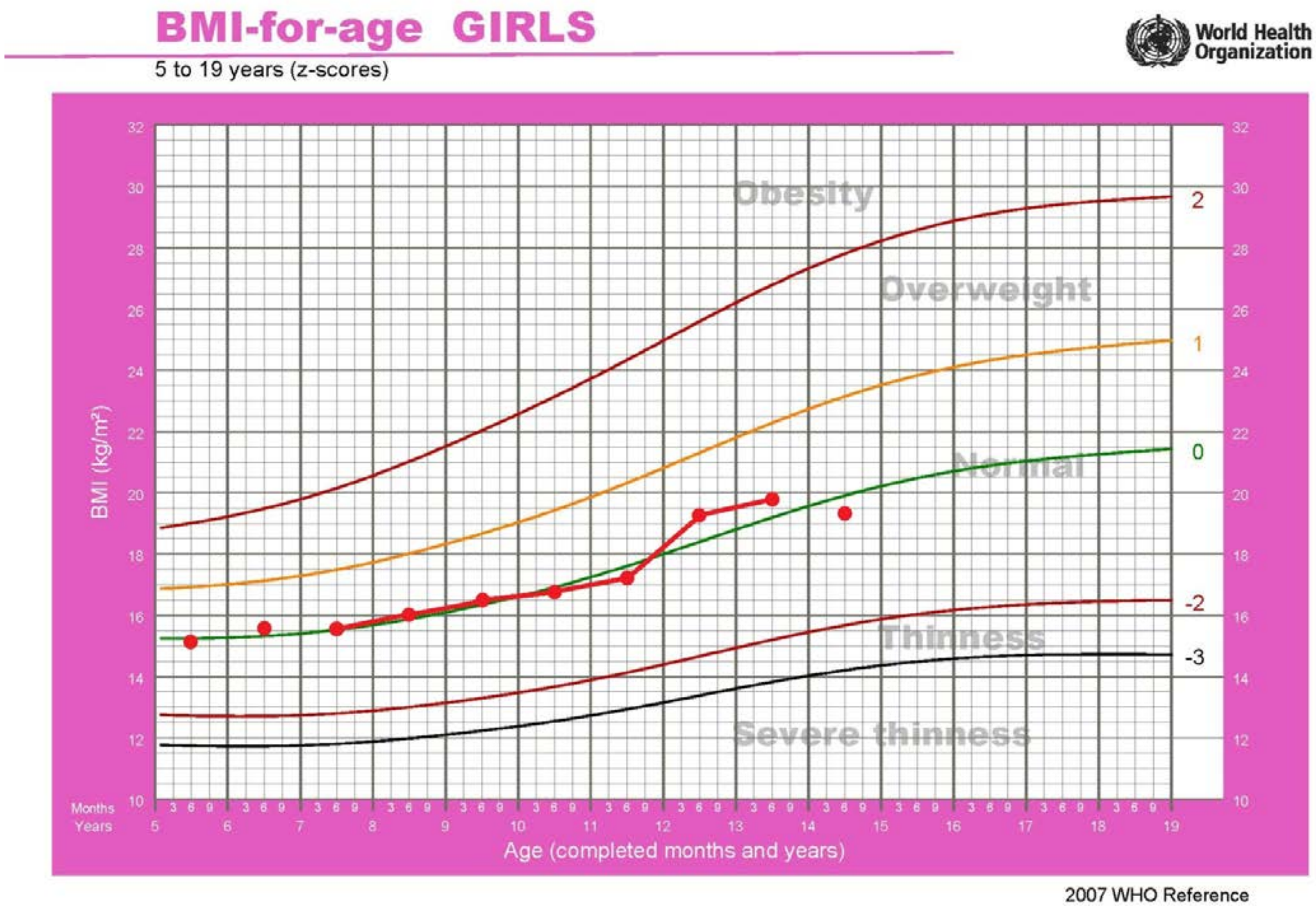
***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

Figure 4.6: Marshallese boys compared to the WHO 2007 Body Mass Index-for-age reference



***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

Figure 4.7: Marshallese girls compared to the WHO 2007 Body Mass Index-for-age reference



***Marshallese averages for each age category are marked with a red dot. If the Marshallese average is significantly different from the WHO reference, a red diamond surrounds the dot. Dots are not connected by a line if they have less than 20 individuals in the sampled age group.**

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Chapter 5: A Comparison of Public and Private School Children on Majuro

Introduction

In the previous chapter, I examined the overall nutritional health of Marshallese school children. Compared to the World Health Organization (WHO) 2007 reference values, I found that Marshallese boys and girls in our sample were statistically significantly lower in average height at every age category. Both males and females were lower, on average, in weight-for-age across all age groups as well. Clinically speaking, the prevalence of stunting, classified as -2 standard deviations below the 2007 WHO reference means for each age group, was 31% and 38.7% for males and females, respectively, in our sample. Yet, surprisingly, none of the Marshallese males or females in our sample was classified as "Severely Thin" and only three of the Marshallese males were considered "Thin" according to their body mass index. What this suggests is that although Marshallese males and females have considerably shorter heights compared to the reference, the extent of lower weights compared to the reference is not as severe. The disproportionate relationship leads to higher ratios in their body mass indices. This finding results in the calculation of "average" body mass indices for a majority of the sample compared to the 2007 WHO reference. In fact, body mass index actually revealed prevalent rates of overweight children, and to a lesser degree, obesity. Although this finding may reflect a secular trend in growth data, the results from the height-for-age and weight-for-age indices give pause.

As stated in the introductory chapter, this project began due to a pilot study developed in 2006 by a local committee of young professionals and government workers to investigate claims that private school children were outperforming public school children in growth and academics. The pilot study revealed statistically significantly lower averages in height and weight among public school children when compared to private school children. Test scores and attendance were also found to be higher among private school children in that pilot study. As was tested in the previous chapter, the validity of the results of this pilot study were unfortunately found to be suspect due to the inclusion of self-reported data (e.g., age), the absence of standardized anthropometric techniques, and a lack of repeated measures to determine the precision and reliability of the measurements taken.

Two of the original goals of the committee's pilot study were to get an idea of the prevalence of undernourishment in children living on Majuro and then to compare children in public schools (who receive no school lunch or breakfast) with those in private schools (who do receive a school lunch and/or breakfast). The previous chapter met the first goal by identifying the prevalence of undernutrition of all sampled children attending school on Majuro Atoll. With the prior methodological errors addressed in the present study, I now approach the comparison of growth measures between the public and private school children.

The pilot study had two testable hypotheses and I will propose them again here. Of course, the 2006 pilot study utilized the CDC 2000 growth reference due to the absence of the WHO 2007 growth reference, published in 2007. Therefore, the following hypotheses are adjusted to reflect this dissertation's current and appropriate methodology:

Hypothesis 1: There are no significant differences between the average height-for-age, weight-for-age, and BMI-for-age z-scores when comparing students attending Majuro primary public and private schools. Body composition measurement z-scores will reveal no significant differences between the two groups as well.

Hypothesis 2: Each of the groups sampled, public and primary school children, will not statistically significantly differ in their average attained growth measure z-scores when compared to the WHO 2007 reference population (deOnis 2007).

Additional Methodology

This comparison will use 308 males and 262 females (570 total) ranging from 5 to 14 years of age. This reduction in sample size from 588 to 570 Marshallese children was the result of missing birth certificates at the child's school and the inability to confirm the child's actual age. Another reduction occurred due to the small sample size of children in the age categories of four and fifteen years.

The children were divided into two categories to test my hypotheses; these categories were attendance at public versus private schools on Majuro. Our sample included 513 children attending public schools and 57 children attending private schools on Majuro Atoll. This sample configuration requires the combination of the age and sex groups because the division of the private school children into different age and sex categories would not yield a large enough sample for statistical analysis. The z-scores calculated for each anthropometric measurement allows me to combine the age and sex categories for public and private school children. The z-scores are representations of the number of standard deviations away from the reference mean and this calculation takes age and sex of the child into account. Therefore, it allows me to look at total data trends for all children attending either a private or public school while acknowledging growth differences between the ages or sexes within the groups.

Public vs. Private School Sample Composition

On first glance, the sampling of private school children appears very disproportionate to the public school children in our sample. Table 5.1 displays the distribution of children sampled from Majuro schools. Each potential school available for sampling is listed in the table as well. One can see the number of children sampled from each school and the percentage our sample represents from each school. Our sample shows approximately a 90/10 percent split between public and private school children.

Only one public school, Ajeltake Elementary, was not sampled and this occurred because multiple parent-teacher association (PTA) meetings were cancelled during the study period. The investigator was not able to present the project to parents or the teachers and so informed consent could not be delivered to parents. Delap Elementary represents just over a third of our sample of public school children. Rita, Uliga, and Delap elementary are located in the "urban" or most populated areas of the atoll. Together, they represent over 58 percent of the elementary school children sampled.

The definition of "urban" or "rural" communities on Majuro is a novel concept introduced here. Gittelsohn (1998) defined all of the communities on Majuro as "urban", but this study accepts that there are individual differences among the communities on Majuro. This concept will come into further focus later in this chapter as well as in later chapters. A point of admission will be made though, that these schools, especially Delap, may have been oversampled. This potential oversampling was not by design. As stated in the methodology chapter, some schools were very open about participation in the study and I was allowed to visit these schools a number of days. Other school principals only allowed for fixed days to sample the student body. Limited by schedules and the retrieval of informed consents and child assents, convenience sampling directed the number of children measured at each location. Overall, 13.2% of the potential student body was sampled from the public schools located on Majuro.

Although there appears to be a disproportionately low number of sampled children from private schools when compared to the public schools, the representation of private school children is not discouraging. There were seven private schools located on Majuro that were available for potential sampling in 2008 and 2009. Unlike the public schools where permission was granted by the Ministry of Education for this project to occur, each private school required permission from a private school board and administration for sampling. Rita Christian School decided not to participate in the study. Transportation issues limited my access to meet with Ajeltake Christian Academy and Laura Seventh Day Adventist (SDA) schools. Delap Seventh Day Adventist school did not grant full approval for participation into the study until one month before the cessation of the study enrollment period. Despite these setbacks, 4.4% of the potential private school children were sampled for my study. Furthermore, unlike the public school system where seventh and eighth graders attend a separate middle school and adolescents attend Majuro High School, private schools include grades kindergarten to 12th grade. Unfortunately, the distribution of these children among each private school was not available. The numbers represented in Table 5.1 were reported to the Ministry of Education and the investigator was granted access to this information. So, some misrepresentation occurred here with the reported proportion of sampled private school children. Therefore, in all probability, the reported proportion of private school children sampled here was much higher for the study's selected age range. Despite this point, the proportion of private school children in my sample was not as high as our public school sample, but I was still be able to reasonably statistically compare the two groups. Overall, my study sampled at least 11% of all children attending Majuro schools. A good study goal would have been equal representation of numbers in each sample, private and public schools, as I was trying to compare growth between two environments. Yet, the selective participation of the private schools limited this goal.

Public vs. Private School Comparison

Table 5.2 displays the nutritional and anthropometric measurements for the public and private school children in our sample. The mean z-score and standard deviation for each group is listed in the table. Independent samples t-tests were used to compare the two groups for each measurement. A very prominent trend becomes clear when looking for statistically significant differences between the two groups. I can reject hypothesis 1 and state that there was a statistically significant difference in average z-scores among height-for-age, weight-for-age, and body mass index-for-age. The private school children were taller, weigh more, and had higher body mass indices than the public school children. One issue with the results here is that I cannot ascertain whether the private school sample obtained is representative of the other private school populations that chose not to participate. I will return to this point later in the dissertation.

These statistically significant differences are further displayed in Table 5.3 and Figures 5.1-5.3. Table 5.3 displays the count data for the sampled private and public school children and places them into z-score categories. The Marshallese children have been placed in the category of z-score as based upon their individual measurements in comparison to the WHO

2007 reference. Figures 5.1-5.3 graphically represent this count data. Although the public and private school children overlap near the reference mean, the edges of the distributions for height-for-age, weight-for-age, and body mass index-for-age consistently show the public school children falling below the reference mean and the private school children close to or above the reference mean.

The count data from Table 5.3 allows me to classify the public and private school children in terms of stunting, underweight, thinness, overweight, and obesity. The rates of malnutrition for public and private school children can be seen in Table 5.4. A z-test for two population proportions was completed with each malnutrition category. This test is used when you want to know whether two populations or groups differ significantly on some single (categorical) characteristic. One of the striking findings here was the rate of stunting found among the public and private school children. Public school children had a rate of stunting (36.70%) more than double the rate of stunting found among private school children (15.80%). This rate was statistically significantly different among the two school groups ($Z=3.15$, $p=0.002$). This suggests that the public school children are dealing with more long term or chronic issues with malnutrition. The only other rate that revealed a striking difference was the classification of overweight. The public school children had an overweight classification rate of 7.80% compared to 22.80% for the private school children. These rates were also statistically significantly different ($Z=-3.69$, $p<0.001$). Although the classifications of thinness, overweight, and obesity are suspect due to the proportional issue found with height-for-age and weight-for-age, it is interesting that the private school children had higher rates of overweight and obesity. Gittelsohn (1998) found that in urban areas, lower SES was associated with higher rates of obesity. The assumption was made in this dissertation that children attending public schools were of a lower socioeconomic status. My findings show an opposite trend where private school children, or higher socioeconomic status, were associated with a higher rate of overweight and obesity.

The trend in Table 5.2 found with height-for-age, weight-for-age, and body mass index-for-age z-scores, for the most part, continued with body composition measurements as well. In terms of sitting height index, which again, is a proportion of the axial skeleton length compared to the overall height of the individual, public school children displayed a statistically significant trend to have their axial skeleton representing a larger proportion of their overall height. I will suggest this finding supports the decreased growth of the long bones in the appendicular skeleton possibly due to malnutrition and other insults to the growth of public school children. Upper arm muscle by height z-scores did not reveal a statistically significant difference though. In the previous chapter, I discussed the issue with missing data calculations. A number of children's measurements could not be calculated since their height was not represented in Frisancho's (1990) reference for upper arm muscle area by height. Their heights were shorter than represented in the reference table. The assumption is that if these children could be represented here, I would see a clear statistical difference between the public and private school children. This point is further strengthened by the fact that only one private school child was not represented here as compared to the 69 public school children omitted.

Table 5.5 (Part I and II) presents similar data as Table 5.2, but the average z-scores for public and private school children were compared to the reference median. A one-sample t-test with a criterion of zero, which represents the mean z-score of the reference, was used to test the statistical difference between the public and private school children and the WHO 2007 reference for each nutritional and anthropometric measurement z-score. For the public school children, every measurement z-score was statistically significantly different from the reference mean except for body mass index-for-age z-score. This result is most likely due to the fact that both height and weight for the public school children were lower than the reference median. Since body mass index is a proportion of weight to height, if the children were more stunted than underweight, the calculated body mass index would not necessarily appear different from the reference median.

The majority of measurement z-scores were statistically significantly different from the reference mean for the private school children as well. One difference to note here is the weight-for-age z-score. Although only children less than ten years of age were represented here due to the limits of the WHO 2007 reference, no statistically different result was found with the weight-for-age z-score average. The private school children could be described as having a shorter height on average compared to the reference, but similar weight compared to the reference. Just like the public school children, the proportion of weight to height was offset and the result was a body mass index z-score higher than the reference mean. This higher body mass index z-score was statistically significantly different. Another result that was not statistically different for private school children was the upper arm fat area z-score average. The public school children z-score average for upper arm fat area was below the mean whereas the private school z-score average was above the reference mean. Although it is of note that it fell above the reference median it was not considered statistically different as compared to the public school z-score average.

Overall, almost all of the public and private school children z-scores for each measurement were statistically different from the reference population. Although the assumption would be that both the private and public school children fall below the reference population for all growth measures, one interesting point to note here was the z-scores for skinfolds. With the exception of the public school children's triceps skinfold z-score average, the 2008-2009 Marshallese sample had average z-score measurements falling above the reference mean for each measurement. This phenomenon was seen with subscapular skinfolds in the last chapter when the groups were examined as a whole. In regards to the triceps skinfolds, the entire sample revealed little to no significant differences from the reference. Once the sample was separated into public and private school children, the triceps skinfold z-score averages displayed significant differences with both groups. The public school children fell below the reference mean while the private school children lay above the mean. Returning to subscapular skinfolds, the previous chapter saw the subscapular skinfold z-score averages for the whole sample falling above the reference mean and the same result was seen when I divided the sample into public and private school children.

The results from Table 5.5 suggest that I may reject our second proposed hypothesis and state that both private and public school children were statistically significantly different in their average attained growth when compared to the mean of the WHO 2007 reference. The main point to take away from this discussion regarding skinfolds, and expanding to the other measurements, is that private school children appear to be "outperforming" public school children in nutritional and anthropometric growth measures. Despite this "better performance" in growth, the majority of average growth measures for private school children fell below the reference mean and was statistically significantly different. In chapter 2, Uliajszek (1994) suggested comparing the children from the highest socioeconomic groups from a developing country in order to assess differences expressed between genetically- and environmentally-driven factors. If the sample of private school children do represent the highest socioeconomic group of Marshallese children, then these findings suggest that Marshallese children do have a genetically-driven growth potential less than the reference population. The reference population would be an American sample here as discussed in chapter 2.

Exploration of Growth Measures within the Private School Sample

The separation of the Marshallese sample into public and private school children revealed significant differences in nutritional and anthropometric measurement z-scores. This consideration is important as it introduces the idea that differences exist between the two groups that ultimately affect the growth and nutritional status of Marshallese children. These potential differences and how they may impact our findings are explored in the next chapter, but due diligence would dictate that a researcher should question whether or not additional differences are seen within each of our groups, public and private school children.

Table 5.6 compares private school children attending Assumption and Majuro Cooperative. SDA Delap was not included in this additional analysis because only six children were sampled from this school and this sample size was too small for appropriate statistical analysis. The results present an interesting situation as a majority of the nutritional and anthropometric measurement z-scores were statistically significant different between children attending these two private schools. For every statistically significant difference found between these two private school samples, Majuro Cooperative children appear to be "outperforming" children attending Assumption. Only three measurement z-score differences were non-significant. These included upper arm muscle area, sitting height and upper arm muscle area by height z-scores. Thus, the data illustrate that children attending Majuro Cooperative in my sample were taller and have more body fat on average. The sitting height index z-score difference suggests that the appendicular skeleton, or legs in this case, had more growth occurring in the Majuro Cooperative children as well.

Finding these differences led to comparison of the Assumption and Majuro Cooperative samples to the public school children. Table 5.7 compares the average measurement z-scores between children attending Majuro Cooperative and public schools on Majuro. Not surprisingly, almost every measurement category was statistically significantly different among these two groups. If one examines Table 5.7, they will see that the Majuro Cooperative school children were “outperforming” public school children, on average, in both nutritional and anthropometric measurements. The one growth measure not statistically significant was upper arm muscle area by height. As I have discussed multiple times previously, the missing data in the public school children sample was most likely responsible for this result.

Table 5.8 displays the comparison of nutritional and anthropometric measurement z-scores among children attending Assumption and public schools. Only height-for-age average z-scores significantly differed statistically among these two groups. This finding does cause alarm as the Assumption school children, overall, did not differ from our public school sample. However, some explanations may be suggested for this finding. First, both Assumption and Majuro Cooperative offer scholarships to children whose families cannot afford to send their child or children to these schools. Assumption offers scholarships to almost a quarter of the children attending their school. Assumption receives money from the Catholic Church to fund these types of scholarships. Assumption also funds these scholarships through multiple gift shops located on the island. In comparison, less than five percent of the children attending Majuro Cooperative receive these types of scholarships. Therefore, sampling from Assumption may include children who would normally attend public schools. Another explanation may be that our private school samples were small enough to cause issues with our statistical analysis. But, the variances for both samples have been considered equal using Levene's test of variances among the samples. Levene's test is an inferential statistic used to assess the equality of variances for a variable calculated for two or more groups. A third explanation, which is expanded upon in the next chapter, may be that children attending Assumption represent a step-wise progression in growth measures between public school children and those attending Majuro Cooperative. There are two things to consider with children attending Majuro Cooperative. These include the possibility of genetic admixture where one parent is American or other nationality as well as the family lineage (e.g., Irooj, Alab, and Rijerbal) of many of the children attending the school.

Exploration of Growth Measures within the Public School Sample

The findings from the with-in private school comparison cause some issues with our original hypotheses. To further explore the validity of my private and public school groups, I will now turn attention to the public school children and comparisons among these various schools. There were eight public schools representing the 2008-2009 sample and sixteen nutritional and anthropometric measurements that were compared. For the sake of space, these comparisons have been presented in Table 5.9, but the table has been split into two parts. In order to compare the eight schools, analysis of variance was used for each average measurement z-score. Any statistically significant difference was followed up with a Bonferroni or Tamhane post-hoc test, depending on whether or not the variances between the two groups were assumed equal. Post-hoc analyses are used to look at patterns in the data that were not specified before the study began. Post-hoc tests look for patterns and/or relationships between subgroups and in the case used here; compare each individual public school to each of the other public schools sampled. Using a Bonferroni post-hoc test on more than 5 groups can lead to some potential error, but consultation with Curtis Ramsey, a biostatistician, led to the acceptance of what would likely be a small amount of error here (personal communication, April 2014). Another consideration to be made was that children from all of the elementary schools would be attending Majuro Middle School for seventh and eighth grades. Therefore, the sample of children attending Majuro Middle School was an amalgamation of the seven public elementary schools sampled. The inclusion of the middle school children might have revealed if growth improves or gets worse the older the children got.

Table 5.9 Part I displays the average z-scores and standard deviations for height-for-age, weight-for-age, body mass index-for-age, total upper arm area, upper arm muscle area, upper arm fat area, arm fat index, sitting height, and sitting height index. The only statistically significant differences found among our nutritional and anthropometric measurements here included upper arm fat area ($F=2.35$, $p=0.02$), arm fat index ($F=2.68$, $p=0.01$), and sitting height index ($F=2.57$, $p=0.01$). Starting with upper arm fat area, post-hoc tests revealed statistically significant differences between children attending Delap and Laura ($p=0.008$) or Ejit ($p=0.045$) Elementary. Post-hoc tests revealed statistically significant differences in arm fat index between

Uliga and Laura (p=0.031) Elementary as well as Delap and Laura (p=0.014) or Ejit (p=0.022) Elementary schools. Sitting height index average z-scores differed between Rairok and Delap (p=0.013) and Ejit (p=0.035) Elementary schools.

Table 5.9 Part II displays the average z-scores and standard deviations for elbow breadth, mid-upper arm circumference, triceps skinfold, subscapular skinfold, sum of skinfolds, and upper arm muscle area by height. Statistically significant differences were found for triceps skinfolds (F=2.64, p=0.01), sum of skinfolds (F=1.90, p=0.07), and upper arm muscle area by height (F=2.54, p=0.01). Beginning with triceps skinfolds, post-hoc tests revealed statistically significant differences between children attending Delap and Laura (p=0.011) or Ejit (p=0.016) Elementary schools. The sum of skinfolds had statistically significant differences between Laura and Delap (p=0012) and Rairok (p=0.048) Elementary schools. Upper arm muscle area by height revealed statistically significant differences between Woja and Uliga (p=0.02) Elementary schools. Considering only the nutritional assessment measurements, the public school children did not statistically differ. Differences between the public school samples mainly reflected measurements of body fat composition and growth in the appendicular skeleton. I shall explore reasons for this difference among children attending public schools in the next chapter, but it should be apparent that our public school children are relatively similar in their nutritional and anthropometric growth measurements.

Conclusion

My initial results indicate that there was a statistically significant difference between the public and private school children for their average nutritional and anthropometric measurement z-scores. Public school children were, on average, below the mean of the reference population. In comparison, the private school children were also below the mean of the reference population but the difference in z-scores was not as great. In the case of skinfold measurements, both groups lay above the reference mean. The public school children's averages were significantly lower than the private school averages. These results allowed me to reject both of my proposed hypotheses.

The children from both public and private school systems revealed a large number of individuals as stunted and a smaller number classified as mildly undernourished. Although the number of individuals placed in this category could be considered noteworthy, it is the moderate and severe categories that should be of utmost concern. These children were identified and the Ministry of Health has taken appropriate measures in an attempt to improve their nutritional status.

Low weight-for-age can represent malnourishment acutely, or in recent time. Low height-for-age can tell something about chronic, or long term, malnourishment occurring among these children. Keeping these temporal frameworks in mind, it should be noted that the public school children displayed signs of malnourishment on both acute and chronic levels. Rates of undernutrition were more prevalent with the public school sample than the private school sample. The private school children appeared to be obtaining a more calorie and nutrient appropriate diet and experiencing less environmental insults than the public school children. This point was reflected in the initial impetus to complete the pilot study. Private schools provide a school lunch where the Marshallese public school system does not have the funding to provide such meals. The differences found in nutritional and anthropometric measurements could be connected to the nutritional education received and higher family socioeconomic status of the private school children. Malnutrition can be linked to other issues such as infection rates and access to clean water as well and these factors are considered in the following chapter.

Many studies have found a positive effect on growth, attendance, and exam scores of children given a meal during school hours (Florence 2008, Taras 2005, Scrimshaw 1998, Pollitt 1995). This analysis was consistent with the findings of these previous studies. Although I do not report academic performance and attendance here, I have explored the growth of Marshallese children. The Republic of the Marshall Islands (RMI) is a relatively new country that is struggling to build an economy and sustainable infrastructure. The importance of programs like school lunch is often overlooked due to their required cost and difficult implementation. A few public schools do attempt to offer 'plates' from time to time consisting of rice and a piece of chicken or a slice of SPAM. These meals are infrequent though and occur when parents are able to volunteer time and resources. A previous nutritional recall on primary school children found a large proportion of Majuro children missing both breakfast and lunch (Pooley, deBrum, Kuniyuki 2000). These children reported eating snacks during school hours and getting their first complete meal at dinner time. If breakfast was consumed, this meal included foods such as bread, rice, donuts, pancakes, water, tea and Kool-Aid. Lunches consumed usually included rice complemented by SPAM, corned beef, canned tuna, or turkey tail (Pooley, deBrum, Kuniyuki 2000).

An important issue with my findings was the difference found between two of our private schools, Majuro Cooperative and Assumption. Although differences did exist among some of our public schools, they were not as extensive. In 2004, a team of WHO researchers visited a number of Pacific Island nations, which included the Republic of the Marshall Islands (Hughes et al. 2004). This study was discussed extensively in the literature review and the previous chapter. The team surveyed two different communities on Majuro including the area known as 'Rita' and 'Laura'. They sampled 56 males and 43 females from Rita and 85 males and 88 females from Laura. Their results are of interest to this study as height-for-age z-scores revealed a stunting rate of 25.3% for Rita and 32.5% for Laura. The 2008-2009 sample revealed a rate of stunting of 32.4% for Rita and 38.2% for Laura. Two points of interest emerge here. First, I continue to see a difference in stunting from the Rita children to the Laura children. One should consider what might be different between these two communities. Second, the rates of stunting in the 2008-2009 sample have increased compared to this study from 2004. This WHO team sampled children from Laura and Rita Elementary children, but something to consider here is if the Hughes et al. (2004) study included private school children in their sample.

Exploring weight-for-age z-scores, Hughes et al. (2004) found an underweight rate of 8.1% for Rita and 16.2% for Laura. The 2008-2009 sample revealed an underweight rate of 13.6% for Rita children and 8.7% for Laura children. In my sample, more children from Rita were considered underweight compared to the Hughes et al. study. Again, the inclusion of private school children in the Hughes et al. study might explain this change. Another thing to consider involves the issue with the WHO 2007 reference and the cessation of collection of weight-for-age data at the age of ten. There may be age differences in the expression of underweight, and possibly, other malnutrition categories.

One important question going forward is what is happening in Laura that causes higher rates of stunting compared to Rita? Why did I find the significant differences among skinfolds of various communities between our public schools? Why was there such a difference found between our private schools? Jelliffe and Jelliffe (1989) have stated there is a general consensus that cross-sectional surveys of growth of young children provide an excellent opportunity for determining the health and nutritional status of a community. Yet, my exploration has led to further questions when I compared the particular facets or sections of the Majuro community. This exploration continues in the next chapter.

Table 5.1: Distribution of 2008-2009 Study Participants by Majuro Schools

	n	% of Sample	N Total	% of School
Public School				
Rita Elementary	71	12.5	866	8.2
Uliga Elementary	47	8.1	308	15.3
Delap Elementary	219	38.4	607	36.1
Rairok Elementary	34	5.9	500	6.8
Ajeltake Elementary			357	
Woja Elementary	18	3.2	150	12.0
Laura Elementary	34	6.0	400	8.5
Majuro Middle School	52	9.1	617	8.4
Ejit Elementary	38	6.7	71	53.5
Total	513	89.9	3876	13.2
Private School*				
Assumption	26	4.6	300	8.7
Majuro Cooperative	25	4.4	280	8.9
SDA Delap	6	1.1	315	1.9
Ajeltake Christian Academy			48	
Rita Christian School			284	
Laura SDA			35	
Uliga Protestant			40	
Total	57	10.1	1302	4.4
				Percent of Potential Majuro Sample
Accumulative Total	570	100	5178	11.0

*Private school N Totals represent all children attending including kindergarten to 12th grade.

Table 5.2: Public vs. Private School Z-Score Comparison

	Public (n=513)			Private (n=57)			t	p
	n	Mean	Standard Deviation	n	Mean	Standard Deviation		
Height for Age	512	-1.71	0.87	57	-0.93	1.00	-6.32	<0.001*
Weight for Age	250	-0.98	0.91	28	-0.33	1.36	-2.49	0.019*
Body Mass Index for Age	511	-0.06	0.88	57	0.42	1.11	-3.12	0.003*
Total Upper Arm Area	513	-0.69	-0.67	57	-0.29	0.93	-3.14	0.003*
Upper Arm Muscle Area	513	-0.99	0.65	57	-0.78	0.72	-2.28	0.023*
Upper Arm Fat Area	513	-0.25	0.68	57	0.19	1.01	-3.18	0.002*
Arm Fat Index	513	0.27	0.77	57	0.67	0.95	-3.05	0.003*
Sitting Height	513	-0.91	0.84	57	-0.45	0.96	-3.79	<0.001*
Sitting Height Index	513	1.26	0.76	57	0.83	0.77	4.08	<0.001*
Elbow Breadth	513	-1.68	0.78	57	-1.32	1.02	-2.58	0.012*
Mid Upper Arm Circumference	513	-0.75	0.74	57	-0.32	0.98	-3.27	0.002*
Triceps Skinfold	513	-0.07	0.73	57	0.39	1.03	-3.23	0.002*
Subscapular Skinfold	509	0.39	0.91	57	0.78	1.39	-2.07	0.042*
Sum of Skinfolds	509	0.17	0.82	57	0.61	1.21	-2.70	0.009*
Upper Arm Muscle Area by Height	444	-0.11	0.64	55	-0.12	0.92	0.10	0.924

*p < 0.05, statistically significant

Table 5.3: Categorization of Public and Private School Children Based upon Their Z-score Measurements

	-4	-3	-2	-1	0	1	2	3	4	Missing	Total
Public											
WHOHAZ[1]	2	33	153	220	104					1	512
WHOWAZ[2]		2	22	106	113	4	3			263*	250
WHOBMIZ[3]			3	68	387	40	11	2		2	511
Private											
WHOHAZ[1]			9	18	28	2				0	57
WHOWAZ[2]			2	9	11	4	1	1		29*	28
WHOBMIZ[3]				5	36	13	1	2		0	57

*Due to the restrictions of the WHO 2007 reference, only children less than ten years of age are examined

[1]Height-for-Age z-score as determined by comparison to the World Health Organization 2007 reference
[2]Weight-for-Age z-score as determined by comparison to the World Health Organization 2007 reference
[3]Body Mass Index-for-Age z-score as determined by comparison to the World Health Organization 2007 reference

Table 5.4: Rates of Malnutrition Among Public and Private School Children

	Public School Children	Private School Children	Z	p
Stunting (%)	36.70%	15.80%	3.15	0.002*
Underweight (%)	9.60%	7.10%	0.42	0.67
Thinness (%)	0.50%	0.00%	0.58	0.56
Overweight (%)	7.80%	22.80%	-3.69	<0.001*
Obesity (%)	2.50%	5.30%	-1.18	0.238

*$p < 0.05$, statistically significant

Table 5.5: Z-Score Comparisons of Public and Private School Children to the WHO 2007 Reference (Part I)

	Public (n=513)				
	n	Mean	Standard Deviation	t	WHO 2007 Comparison p
Height for Age	512	-1.71	0.87	-44.44	<0.001*
Weight for Age	250	-0.98	0.91	-17.15	<0.001*
Body Mass Index for Age	511	-0.06	0.88	-1.42	0.158
Total Upper Arm Area	513	-0.69	-0.67	-23.18	<0.001*
Upper Arm Muscle Area	513	-0.99	0.65	-34.46	<0.001*
Upper Arm Fat Area	513	-0.25	0.68	-8.24	<0.001*
Arm Fat Index	513	0.27	0.77	7.93	<0.001*
Sitting Height	513	-0.91	0.84	-24.36	<0.001*
Sitting Height Index	513	1.26	0.76	37.41	<0.001*
Elbow Breadth	513	-1.68	0.78	-49.05	<0.001*
Mid Upper Arm Circumference	513	-0.75	0.74	-23.19	<0.001*
Triceps Skinfold	513	-0.07	0.73	-2.04	0.042*
Subscapular Skinfold	509	0.39	0.91	9.54	<0.001*
Sum of Skinfolds	509	0.17	0.82	4.66	<0.001*
Upper Arm Muscle Area by Height	444	-0.11	0.64	-3.53	<0.001*

*p < 0.05, statistically significant

Table 5.5: Z-Score Comparisons of Public and Private School Children to the WHO 2007 Reference (Part II)

	Private (n=57)				
	n	Mean	Standard Deviation	t	WHO 2007 Comparison p
Height for Age	57	-0.93	1.00	-7.00	<0.001*
Weight for Age	28	-0.33	1.36	-1.27	0.216
Body Mass Index for Age	57	0.42	1.11	2.85	0.006*
Total Upper Arm Area	57	-0.29	0.93	-2.32	0.024*
Upper Arm Muscle Area	57	-0.78	0.72	-8.16	<0.001*
Upper Arm Fat Area	57	0.19	1.01	1.41	0.164
Arm Fat Index	57	0.67	0.95	5.31	<0.001*
Sitting Height	57	-0.45	0.96	-3.58	0.001*
Sitting Height Index	57	0.83	0.77	8.12	<0.001*
Elbow Breadth	57	-1.32	1.02	-9.73	<0.001*
Mid Upper Arm Circumference	57	-0.32	0.98	-2.44	0.018*
Triceps Skinfold	57	0.39	1.03	2.83	0.006*
Subscapular Skinfold	57	0.78	1.39	4.22	<0.001*
Sum of Skinfolds	57	0.61	1.21	3.83	<0.001*
Upper Arm Muscle Area by Height	55	-0.12	0.92	-0.96	0.340

*p < 0.05, statistically significant

Table 5.6: Private School Z-Score Comparison

	Assumption			Majuro Cooperative			t	p
	n	Mean	Standard Deviation	n	Mean	Standard Deviation		
Height for Age	26	-1.19	0.94	25	-0.41	0.88	-3.04	0.004*
Weight for Age	13	-0.76	1.00	10	0.59	1.54	-2.41	0.029*
Body Mass Index for Age	26	0.09	0.91	25	0.90	1.14	-2.80	0.007*
Total Upper Arm Area	26	-0.59	0.66	25	0.13	1.06	-2.91	0.005*
Upper Arm Muscle Area	26	-0.85	0.62	25	-0.61	0.80	-1.18	0.244
Upper Arm Fat Area	26	-0.21	0.59	25	0.70	1.19	-3.48	0.001*
Arm Fat Index	26	0.23	0.65	25	1.19	1.02	-4.00	<0.001*
Sitting Height	26	-0.59	1.02	25	-0.16	0.88	-1.59	0.118
Sitting Height Index	26	1.08	0.72	25	0.45	0.70	3.17	0.003*
Elbow Breadth	26	-1.77	0.75	25	-0.64	0.94	-4.74	<0.001*
Mid Upper Arm Circumference	26	-0.64	0.77	25	0.14	1.03	-3.05	0.004*
Triceps Skinfold	26	-0.06	0.65	25	0.95	1.16	-3.80	0.001*
Subscapular Skinfold	26	0.38	0.66	25	1.26	1.87	-2.24	0.033*
Sum of Skinfolds	26	0.18	0.65	25	1.16	1.52	-2.97	0.006*
Upper Arm Muscle Area by Height	24	-0.07	0.92	25	-0.14	0.97	-0.24	0.809

*p < 0.05, statistically significant

Table 5.7: Majuro Cooperative vs. Public School Children Z-Score Comparison

	Majuro Cooperative			Public School Children				
WHO 2007 Reference Z-score	n	Mean	Standard Deviation	n	Mean	Standard Deviation	t	p
Height for Age	25	-0.41	0.88	512	-1.71	0.87	-7.30	<0.001*
Weight for Age	10	0.59	1.54	250	-0.98	0.91	-3.21	0.010*
Body Mass Index for Age	25	0.90	1.14	511	-0.06	0.88	-5.20	<0.001*
Total Upper Arm Area	25	0.13	1.06	513	-0.69	0.67	-3.80	0.001*
Upper Arm Muscle Area	25	-0.61	0.80	513	-0.99	0.65	-2.79	0.005*
Upper Arm Fat Area	25	0.70	1.19	513	-0.25	0.68	-3.95	<0.001*
Arm Fat Index	25	1.19	1.02	513	0.27	0.77	-5.71	<0.001*
Sitting Height	25	-0.16	0.88	513	-0.91	0.84	-4.30	<0.001*
Sitting Height Index	25	0.45	0.70	513	1.26	0.76	5.18	<0.001*
Elbow Breadth	25	-0.64	0.94	513	-1.68	0.78	-6.45	<0.001*
Mid Upper Arm Circumference	25	0.14	1.03	513	-0.75	0.74	-5.79	<0.001*
Triceps Skinfold	25	0.95	1.16	513	-0.07	0.73	-4.32	<0.001*
Subscapular Skinfold	25	1.26	1.87	509	0.39	0.91	-2.34	0.028*
Sum of Skinfolds	25	1.16	1.52	509	0.17	0.82	-3.22	0.004*
Upper Arm Muscle Area by Height	25	-0.14	0.97	444	-0.11	0.64	0.16	0.873

*p < 0.05, statistically significant

Table 5.8: Assumption vs. Public School Children Z-Score Comparison

WHO 2007 Reference Z-score	Assumption			Public School Children			t	p
	n	Mean	Standard Deviation	n	Mean	Standard Deviation		
Height for Age	26	-1.19	0.94	512	-1.71	0.87	-2.98	0.003*
Weight for Age	13	-0.76	1.00	250	-0.98	0.91	-0.86	0.389
Body Mass Index for Age	26	0.09	0.91	511	-0.06	0.88	-0.83	0.409
Total Upper Arm Area	26	-0.59	0.66	513	-0.69	0.67	-0.73	0.464
Upper Arm Muscle Area	26	-0.85	0.62	513	-0.99	0.65	-1.07	0.287
Upper Arm Fat Area	26	-0.21	0.59	513	-0.25	0.68	-0.28	0.783
Arm Fat Index	26	0.23	0.65	513	0.27	0.77	0.24	0.808
Sitting Height	26	-0.59	1.02	513	-0.91	0.84	-1.86	0.063
Sitting Height Index	26	1.08	0.72	513	1.26	0.76	1.16	0.248
Elbow Breadth	26	-1.77	0.75	513	-1.68	0.78	0.57	0.571
Mid Upper Arm Circumference	26	-0.64	0.77	513	-0.75	0.74	-0.77	0.442
Triceps Skinfold	26	-0.06	0.65	513	-0.07	0.73	-0.05	0.959
Subscapular Skinfold	26	0.38	0.66	509	0.39	0.91	0.03	0.973
Sum of Skinfolds	26	0.18	0.65	509	0.17	0.82	-0.05	0.962
Upper Arm Muscle Area by Height	24	-0.07	0.92	444	-0.11	0.64	-0.25	0.860

*$p < 0.05$, statistically significant

Table 5.9: Public School Mean Z-score Comparison Part I

		Height for Age	Weight for Age	Body Mass Index for Age	Total Upper Arm Area	Upper Arm Muscle Area	Upper Arm Fat Area	Arm Fat Index	Sitting Height	Sitting Height Index
Uliga Elementary	n	47	15	47	47	47	47	47	47	47
	Mean	-1.73	-1.10	-0.17	-0.67	-1.15	-0.12	0.47	-0.92	1.35
	Standard Deviation	0.73	1.28	1.06	0.73	0.49	0.86	0.89	0.76	0.71
Delap Elementary	n	219	116	219	219	219	219	219	219	219
	Mean	-1.73	-0.92	0.03	-0.66	-0.98	-0.21	0.32	-0.88	1.33
	Standard Deviation	0.84	0.82	0.86	0.73	0.75	0.71	0.79	0.81	0.80
Rita Elementary	n	71	44	71	71	71	71	71	71	71
	Mean	-1.56	-0.97	-0.13	-0.77	-1.02	-0.36	0.20	-0.76	1.22
	Standard Deviation	1.00	0.92	0.76	0.52	0.62	0.48	0.77	0.91	0.70
Rairok Elementary	n	33	23	33	34	34	34	34	34	34
	Mean	-1.48	-0.73	-0.04	-0.66	-0.90	-0.27	0.26	-0.96	0.84
	Standard Deviation	1.12	1.05	0.82	0.47	0.51	0.41	0.59	1.05	0.68
Woja Elementary	n	18	9	18	18	18	18	18	18	18
	Mean	-1.55	-0.70	0.23	-0.53	-0.75	-0.13	0.35	-0.75	1.23
	Standard Deviation	0.79	0.91	0.90	0.66	0.72	0.54	0.73	0.68	0.68

		Height for Age	Weight for Age	Body Mass Index for Age	Total Upper Arm Area	Upper Arm Muscle Area	Upper Arm Fat Area	Arm Fat Index	Sitting Height	Sitting Height Index
Laura Elementary	n	34	23	34	34	34	34	34	34	34
	Mean	-1.79	-1.25	-0.34	-0.89	-1.03	-0.50	-0.09	-1.14	1.04
	Standard Deviation	0.73	0.81	0.76	0.35	0.40	0.36	0.56	0.76	0.60
Majuro Middle School	n	52	N/A	51	52	52	52	52	52	52
	Mean	-1.76	N/A	-0.02	-0.58	-0.97	-0.07	0.39	-0.93	1.23
	Standard Deviation	0.77	N/A	1.10	0.89	0.63	1.00	0.92	0.87	0.76
Ejit Elementary	n	38	20	38	38	38	38	38	38	38
	Mean	-1.96	-1.38	-0.18	-0.78	-0.95	-0.44	0.00	-1.10	1.42
	Standard Deviation	0.96	0.91	0.74	0.43	0.51	0.33	0.46	0.85	0.85
F		1.27	1.58	1.32	1.14	0.94	2.35	2.68	1.12	2.57
p		0.26	0.16	0.24	0.34	0.48	0.02*	0.01*	0.35	0.01*

*p < 0.05, statistically significant

Table 5.9: Public School Mean Z-score Comparison Part II

		Elbow Breadth	Mid Upper Arm Circumference	Triceps Skinfold	Subscapular Skinfold	Sum of Skinfolds	Upper Arm Muscle Area by Height
Uliga Elementary	n	47	47	47	47	47	42
	Mean	-1.60	-0.74	0.10	0.38	0.26	-0.27
	Standard Deviation	0.81	0.80	0.95	0.96	0.96	0.55
Delap Elementary	n	219	219	219	217	217	186
	Mean	-1.67	-0.72	-0.02	0.42	0.21	-0.13
	Standard Deviation	0.74	0.77	0.75	1.05	0.90	0.62
Rita Elementary	n	71	71	71	71	71	65
	Mean	-1.76	-0.86	-0.18	0.30	0.06	-0.22
	Standard Deviation	0.84	0.70	0.56	0.57	0.57	0.53
Rairok Elementary	n	34	34	34	34	34	30
	Mean	-1.69	-0.70	-0.08	0.48	0.20	-0.13
	Standard Deviation	0.82	0.54	0.48	0.51	0.46	0.52
Woja Elementary	n	18	18	18	18	18	15
	Mean	-1.30	-0.56	0.05	0.48	0.28	0.25
	Standard Deviation	0.73	0.75	0.61	0.55	0.53	0.87

		Elbow Breadth	Mid Upper Arm Circumference	Triceps Skinfold	Subscapular Skinfold	Sum of Skinfolds	Upper Arm Muscle Area by Height
Laura Elementary	n	34	34	34	32	32	33
	Mean	-1.87	-0.98	-0.37	0.07	-0.17	-0.15
	Standard Deviation	0.64	0.43	0.45	0.62	0.48	0.61
Majuro Middle School	n	52	52	52	52	52	42
	Mean	-1.57	-0.64	0.10	0.56	0.36	0.09
	Standard Deviation	0.70	0.93	1.03	1.20	1.15	0.88
Ejit Elementary	n	38	38	38	38	38	31
	Mean	-1.85	-0.84	-0.30	0.24	-0.03	0.10
	Standard Deviation	0.96	0.50	0.37	0.64	0.49	0.53
F		1.52	1.16	2.64	1.16	1.90	2.54
p		0.16	0.33	0.01*	0.32	0.07*	0.01*

*$p < 0.05$, statistically significant

Figure 5.1: Number of Children per Each Height-for-Age Z-score Category

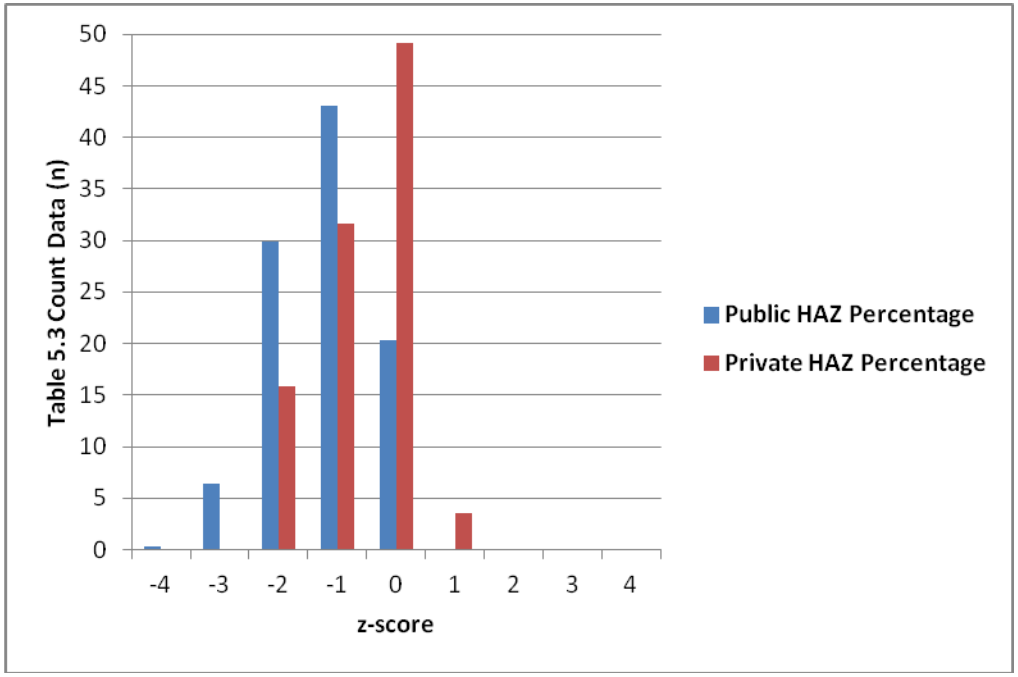


Figure 5.2: Number of Children per Each Weight-for-Age Z-score Category

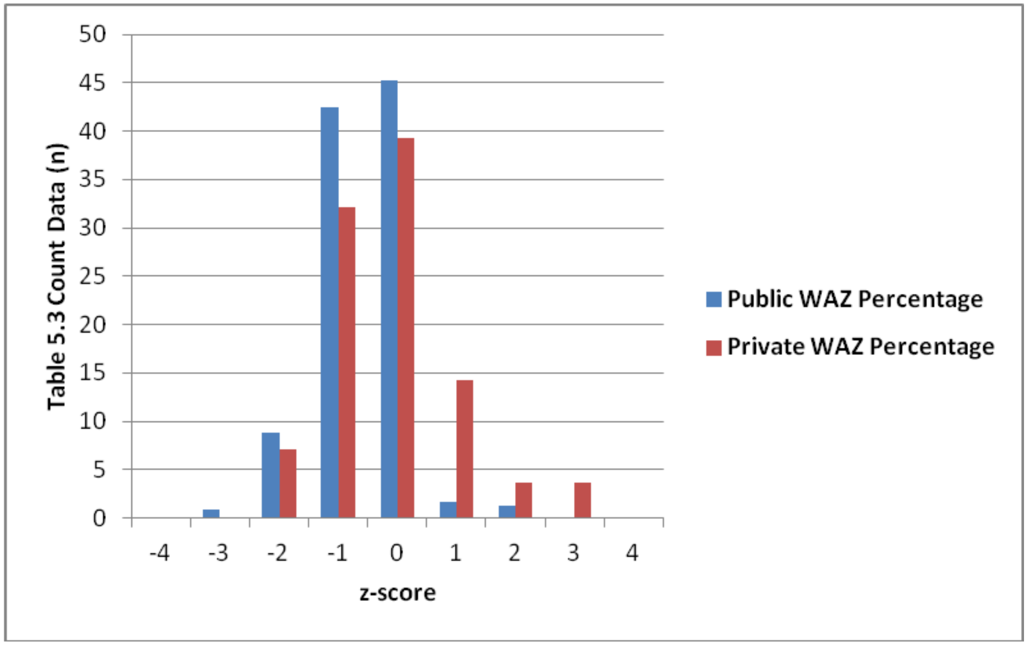
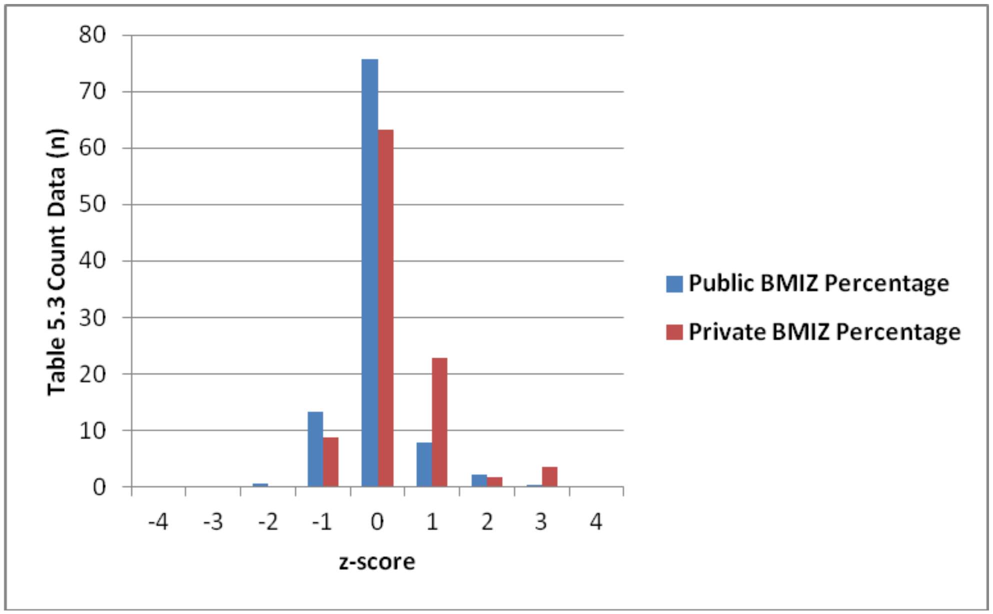


Figure 5.3: Number of Children per Each Body Mass Index-for-Age Z-score Category



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<u>Chapter 6: An Exploration of Majuro Lifestyle, Dietary Habits, and Food Economics</u>

In this chapter, I turn my focus to the Majuro Atoll as a community as a whole. A particular focus is placed upon what constitutes a meal and the foods that Marshallese on Majuro use to create these meals. I begin by reviewing the historical definitions of a Marshallese meal and also explore how ecosystems vary from atoll to atoll. Various ecosystems have been created due to the influence that the outside world has had on the Marshallese. Interviews were conducted with islanders on Majuro during the fieldwork period to gather information on current dietary habits. The results of these interviews are discussed at length. My attention then shifts to the questionnaires that were distributed to parents of children participating in our nutritional and anthropometric survey. Combined, the interviews, questionnaire data, and participant observation build a picture of what current dietary and lifestyle habits look like for islanders living on Majuro. This information is used to further explore what differences exist, specifically social, behavioral, and dietary, between our sample of public and private school children.

Historical and Modern Marshallese Food and Dietary Habits

A Marshallese Plate

A Marshallese meal, or "plate" as it is commonly referred to, is constructed differently from the Western idea of what makes a meal. This point was explored well in Carucci's book, "Nuclear Nativity: Rituals of Renewal and Empowerment in the Marshall Islands" (1997). This work explored the holiday Christmas, or Kirijmoj, from the viewpoint and practiced tradition of Enewetak/Ujelang Islanders. Enewetak Atoll had 853 inhabitants as reported in 1999 (Census of Population and Housing, RMI). One of the major explorations of this ethnography was the adoption of the holiday. The first Catholic missionaries to establish long term churches in the community occurred in the second half of the 19th century. Over time, Western Christmas traditions and rituals were accepted and blended with many Marshallese rituals and symbolism (Carucci 1997). Kirijmoj includes a number of practiced traditions, but especially important to the exploration here, is the discussion in this work on the large prepared feasts for food exchanges.

Carucci explains that all food items were defined as land, sea, or air food. Sea turtle, fish, crabs, and other sea life fall into the obvious category, as do birds. Land foods would include items such as coconut, breadfruit, pandanus (Figure 6.1), taro root, papaya, or banana. A Marshallese plate has traditionally included a land food paired with a sea or air food. This combination constitutes a proper Marshallese plate. This is very different from Western plates as they are usually defined as the combination of a meat, a vegetable, and a starch (Carucci 1997). Each meal comprises edibles that promote the growth and sustenance of living humans with a “gendered” balance of internal, strength-building land foods and external, beauty-fashioning seafoods (Carucci 1997). In the same essence, they are described as staples and complements.

Meals are fashioned according to set patterns that balance items from each category and that, when consumed in proper balance, symbolically represent each gender producing viable living humans (Carucci 1985, Pollock 1992). Drinks and foods, and seafoods and land foods must be properly balanced to symbolically create viable humans. Land foods, or staples, are the unmarked and taken-for-granted category of food that balances drinks and provides for the sustenance and growth of the person’s core. This core is derived from one’s matriclan and is nurtured by female-gathered and female-prepared staple foods (Carucci 1985). Women collect land-grown staples from the female domain. The raw staples such as breadfruit, arrowroot, and now rice and flour, are cooked in various ways by the women.

The staples are balanced first by drinks, prototypical male foods like coconut milk. Men produce foods from the male domain. Pig, uncooked seafoods, fish, drinking coconuts, and baked sprouted coconuts are prepared by men, with whom these foods are associated. A meal, even in famine, requires these minimum female and male components. Land foods are also then complemented by seafoods and birds. They lend balance and strength to the staples and contribute to external beauty with their sweetness and oils/fats. They are thought to contribute to beautiful hair and smooth, reflective skin, perceived qualities of attractiveness or external beauty, but not characteristics that are a requisite part of human existence. Sugar is even thought to have curative properties along with these external characteristics (Carucci 1997, Pollock 1975). A couple of previous studies found that Marshallese rank foods particularly fatty or greasy as most desirable (Tobin 1952, Maifeld and Carucci 1982), and again, these food characteristics are thought to contribute to external beauty. Many combinations of food are thought to be proper, e.g., pig is a perfect complement to certain varieties of breadfruit or fish is best paired with rice (Carucci 1997).

Modern Food Ecosystems

Colonialism and globalization, as discussed in our literature review, occurred in the Marshall Islands throughout the second half of the 19th century and followed through the 20th century. The continued introduction of foreign people throughout the Marshall Islands brought various religions, behaviors and food. Nancy Pollock (1970) addresses the issue of dietary change specifically on Namu Atoll, an outer atoll west of Majuro that reported 903 inhabitants in 1999 (Census of Population and Housing, RMI). The people living on Namu, like any Marshallese atoll, have a strong fear of starvation. Despite this fear, food was traditionally considered a special type of valuable. Marshallese Islanders have previously mentioned that even in times of starvation, food should be given freely and not hoarded (Pollock 1970). So, when new foodstuffs were introduced into the Marshallese ecosystem, they were added to the existing scheme. Western food items such as rice, flour, tea and sugar were welcomed, but eventually, would replace old subsistence foods for comfort and ease. The late 1880s found German traders setting up coconut plantations on atolls located in the Marshall Islands. Small shops opened that would buy copra, or processed coconut, and then allow the islander to buy foodstuffs and goods offered in the shop (Pollock 1975).

Throughout the 20th century, this slow and steady progression of reliance upon imported foodstuffs led to there being three modern types of food-producing ecosystems described on Marshallese atolls. These include the following: an atoll not regularly inhabited because food supply is considered inadequate to support a population; an inhabited atoll where the local flora and fauna have been used to support a population over several generations; and an inhabited atoll where foodstuffs must all be imported because the population is too dense to allow space on which to grow subsistence foods (Pollock 1975).

Pollock (1975) states that Namu islanders purchased foods to supplement locally derived foods. This supplementation made the most sense because it would combat the problems of totally relying on locally derived foods or only purchasing Western, delivered foods. Natural calamities like typhoons, tidal waves, droughts, and high winds, pestilence and crop disease, and warfare or the creation of plantations all could cause limits on locally derived food. Although these problems existed, local foods grew almost everywhere on Namu and Marshallese were used to moving from one part of the island to another so that they did not exhaust resources. Kin links to and trading with other atolls also allowed for a variety of foods that might not grow on Namu. Although fish and other sources of protein were sporadic, the author hypothesizes that the Marshallese might be physiologically adapted to a low protein, high carbohydrate diet. Based upon the discussions by Oomen and Corden (1969) and Hipsley and Kirk (1965), if an atoll population is able to fix nitrogen in the intestine, then a high protein, high fat diet may be unnecessary and harmful.

Relying solely on purchased food items has many problems as well. To begin, Marshall Islanders have been confused about copra production strategies due to the constant change in political control. These policies included price fluctuations of copra, fixed prices of food stuffs, and shipping and communication costs (Carucci 1997). Frequently, a ship with supplies would often be redirected from its schedule due to weather, accidents, and political intervention. Copra dries out quickly and it is difficult to estimate the correct time to process it when ship arrivals are so sporadic. This difficulty obviously conflicted with Marshallese abilities to produce as much copra at the correct time resulting in a loss of money for the islander. Carucci explains that even in 1997, the vast majority of foods needed for Kurijmoj were purchased from the U.S. Department of Agriculture or imported from the governmental center on Majuro (Carucci 1997).

With the advent of Western medicine and Christian values regarding infanticide, the Marshallese population has continually seen growth over the last century. Therefore, Marshallese living on Namu attempted to gather as much food as often as possible. They placed a minimal reliance on Western foodstuffs because of sporadic delivery and there seemed to be a preference for traditional food items, especially when people are sick. With these outlined risks and strategies, Pollock (1975) states that new foods and adaptations were added to old subsistence foods rather than substituting for them on Namu.

There have been a couple of broad surveys of food and indigenous food items in the Republic of the Marshall Islands. The first survey was conducted in 1980 by the Brookhaven National Laboratory in conjunction with the United States Government (Naidu et al. 1980). The goal of this study was to summarize information on diet and living patterns for the Marshallese, specifically in Northern Atolls. The primary purpose of the study was to estimate the dose estimation models of radioactive fallout from U.S. Pacific nuclear tests for the Marshallese still residing on atolls close to these test sites. The report surveyed how local foods were gathered, receipt of food aid, food distributed to the populations displaced as a result of nuclear testing, and the availability of cash for the purchase of imported foods. These northern atolls were found to replace local food gathering with imported food items due to fear that local food was ‘unclean’ and also the convenience imported foods offered (Naidu et al. 1980). Finding a "typical" family in the Marshall Islands on which to base common consumption patterns was difficult though as each individual family consumed variable amounts of local and imported food. The report also described three typical diet patterns or communities. These were divided similar to Pollock’s description of ecosystems above. The first community had maximum availability of local foods, a highly depressed local economy, low population, and little or no ability to purchase imported food. The second community included a low availability of local foods (except fish), was overpopulated, and had a good supply of imported foods. The third community had a low availability of local foods, poor fishing, the presence of large government food programs, it was overpopulated, and had a good supply of imported foods and the availability of cash to buy them (Naidu et al. 1980).

The second of these surveys focused on eleven main starch foods commonly found in Polynesia and Micronesia. Pollock's book from 1992 drew upon historical accounts of information regarding these foods while also exploring explicit and implicit expressions of food habits associated with these staples. Her work addressed the cultural and dietary attachment to traditional food sources despite the availability of Westernized food items. Her work, similar to Carucci's (1997), also highlighted the role food plays symbolically in Pacific Islander's lives, as opposed to the Western construct of "energy input the individual needs in order to function (Pollock 1992:p. 22-24)." Food, in the Pacific, acts as a categorized set of symbols that are both unique and common to each Pacific society. I discussed these points earlier in the chapter as to how they specifically apply to the Marshall Islands. Items such as breadfruit and pandanus or even coconuts still hold great importance for Marshall Islanders in meals, but their frequency in the diet are often challenged by the supplementation of Western foods. Increasingly, these traditional food items appear relegated to holidays and special events on Majuro.

Unfortunately, Majuro Atoll more closely represents a food-producing ecosystem resembling an inhabited atoll where foodstuffs must all be imported because the population is too dense to allow space on which to grow subsistence foods. From modern examinations of Majuro Atoll though, one does not see adaptation such as the islanders on Namu or other outer atolls. The 38,000 people occupying 3.96 square miles has led to much of the land on Majuro being occupied by residences and conveniences associated with any modernized city or capital of a country. There is an international airport, two major chain grocery stores, restaurants, roads, a movie theater, night clubs, government buildings and two major shipping docks for commercial fishing boats and the delivery of imported materials. This modernization does not allow for much of the eastern side of Majuro Atoll to be used for locally derived foods. The most accessible jungle and farming land for islanders living on Majuro is located over thirty miles away on the Western edge of Majuro Atoll, in the community of Laura. There are a couple of farms operated by both Marshallese and Taiwanese farmers located there and they have been in operation now for almost a decade. Although they do grow a lot of fruits and vegetables there, the majority of these food items are either distributed among residents of Laura or they are shipped thirty miles east to be sold in the bigger, chain grocery stores. It is here on Majuro that our exploration turns toward interviews and a parent questionnaire that was distributed among children participating in our nutritional assessment. There are no in depth ethnographies or analyses on how traditional Marshallese dietary habits and foods have changed on Majuro Atoll.

Interviews

A supplementary study was initiated in the summer of 2009 in order to get some understanding of modern Marshallese views and opinions regarding food and dietary habits. This qualitative study involved interviews with structured and unstructured questions. Indiana University IRB approval was granted on July 13th, 2009 (Protocol 08-13421) and thirteen participants from the community were recruited with the use of radio and newspaper advertisements as well as flyers distributed around the community. These recruitment tools were offered in both Marshallese and English languages. If a participant was interested and contacted the investigator, they were offered informed consent. Upon completion of the interview, participants were rewarded with a five dollar gift card to one of the local grocery stores. Participants were not made aware of the incentive until the end of the interview. A copy of interview questions can be found in Appendix H.

The first point of discussion with participants was for them to define the word “nutrition” and then to explain what is included in “good nutrition”. Most people offered a common definition of the word nutrition. Some answers included the combination of eating healthy foods or diets as well as exercise to explain nutrition. One person even mentioned eating a variety of foods “to obtain things your body needs on a daily basis, such as protein, carbohydrates, and fiber.” Another person specifically mentioned obtaining “water” as part of nutrition. A couple of people did not know what “nutrition” was. There also appeared to be a mental connection of nutrition and its effects on the body. A number of the people interviewed associated the need for fruits and vegetables to obtain things such as vitamins and minerals. One person stated that nutrition included foods that were “healthy and safe to eat, such as vegetables, fruit and fish”. Two people mentioned the need for milk as part of “nutrition”. A number of people mentioned diets low in sugar and fried foods as “good” nutrition. Another person defined “Marshallese food” as something required for proper nutrition, with the implication being that imported foods were bad.

For the most part, the interviews discovered some common behaviors in Marshallese households. Everyone interviewed mentioned a meal schedule consisting of breakfast, lunch and dinner and most people ate all three meals or breakfast and dinner with their family. A majority of people also stated that they considered these meals as family time. Only a couple of them considered meals “simply a time to feed one’s self”. On average, their dinner from the previous evening included 4 people sharing the prepared meal. One participant mentioned having 10 people attending the meal. Another stated having over 30 people at the meal. After more explanation, this person had attended a birthday party the previous evening and it was not included in the calculated average. The interviewed participants generally stated that there was no order to who eats in their household. The people who did discuss an order, generally described the women and children as eating first, then the adult men would follow. Nine of the thirteen people interviewed reported cooking meals in a kitchen within their home. The other four reported cooking meals in a cookhouse outside the home. Interestingly, eleven of the interviewees had a refrigerator to preserve their food while two of them used coolers. Most outer atolls in the Marshall Islands do not have running water or electricity and having kitchens and refrigerators are of little use there. On Majuro, kitchens and refrigerators are more common, but many Marshallese still consider these to be “luxury” items. Interview participants were also asked how often their family eats at a restaurant. They were also asked how often they eat at a restaurant without their family. Five of them responded that they never eat at a restaurant with their family and another three stated that they would eat at a restaurant once a month. Seven out of eleven people also stated that they never eat at a restaurant by themselves. I asked them the reason why they did not eat at restaurants more often on Majuro and “Cost” was the answer given every time I asked this follow-up question.

Many questions posed to interviewees involved dietary and food habits of their children. Participants were asked about their attitude towards what their children ate. If asked to elaborate, a clarification was offered. They were then asked if they felt that either "children are little adults and will eat if they are hungry" or "we, as parents, need to ensure that kids eat right, even if they do not want to." Overwhelmingly, everyone stated that "we, as parents, need to ensure that kids eat right, even if they don't want to." Although the answer was unanimous, this question may have been leading or the participants suspected the only correct answer was the latter. One person stated that they "agreed with this point, but that it was hard to enforce." The person actually stated that the preference in Majuro is that they are "little adults and will eat if they are hungry." This question was followed up with two questions directly applying to this attitude. Six of the interviewees stated that their children get to choose which foods they want to eat at meals, while seven stated that the parent decided which foods would comprise meals for their children. The second follow-up question asked if their children get to eat food when they are hungry or if they have to wait to eat at meal times. Ten of the interviewees stated that their children were allowed to eat food, whether that be meals or snacks, when they were hungry. A number of people interviewed indicated that this rule applies to children, but generally not to teenagers. So, although parents seem to agree with the idea that meals should be regulated and guided by parents, half of them stated that their children get to choose which food they want to eat and most children were allowed to seek food when they were hungry.

The last series of questions posed in the interviews revealed some interesting points regarding what types of foods and meals their children preferred and/or what they had to eat the evening before the interview. Participants were asked what types of foods their children normally asked for or what were two of their children's favorite foods. The most common responses included chicken, white rice, ice cream, fish, breakfast cereal and ramen. Other responses included items such as pancakes, pizza, hot dogs, corned beef or other canned meats such as SPAM or mackerel. Only one parent stated that their children liked fruit as their favorite food. This child's other favorite food was recorded as ramen. The participants were also asked to list two foods that their children hate or dislike. The most common answer, which should not be a surprise to anyone, was vegetables, especially the green colored ones. Other foods listed that children disliked included breadfruit, brown rice, pandanus, taro, sashimi and nutrition biscuits. One response even included "American food". The responses to this question are particularly interesting when compared to food ingredients and dishes that are considered "traditionally Marshallese". The most commonly mentioned "traditional Marshallese" foods included fish, breadfruit, pumpkins, bananas, pandanus, coconuts (grated and milk), taro, and papaya. Traditional dishes included boiled breadfruit with coconut cream, ramen with chicken, jaibo (a dish with flour and breadfruit dumplings boiled in coconut cream), preserved pandanus or breadfruit, and coconut rice. What is interesting here is that many of the foods listed as "disliked by Marshallese children" in these households were identified as "traditionally Marshallese". Many of the foods preferred by children were not introduced into the Marshallese diet until the last hundred years. Ramen and rice was not introduced to the Marshall Islands until after World War I when Japan became the protectorate of the Marshall Islands (Carucci 1997). Canned meats, hot dogs, pizza, pancakes, breakfast cereal and ice cream became very popular when the United States took over as their protectorate after World War II. Many of the soldiers stationed on Majuro brought these items and as stores became more common place, they were offered in stores (Carucci and Poyer 2002).

The final question of the interview asked participants to describe a meal or meals their family had consumed over the last day. Every person gave the same response for dinner. This meal consisted of white rice paired with chicken, ham, fish, crab, canned meat, or sashimi. Breadfruit or banana was served with only two of these 13 described dinners. Only one person mentioned having vegetables with their dinner and they elaborated that a can of vegetables was mixed in with their rice. Three interviewees described their breakfast the morning of the interview. One person stated that breakfast consisted of donuts and pancakes. Another person listed nutrition biscuits, cheerios, hard boiled eggs and coffee for breakfast. The last recorded breakfast consisted of white rice, bacon, eggs, donuts, and coffee.

The interviews appear to highlight meals that were lacking in vegetables, high fiber foods, and fruits. Meals consistently included high fat, high calorie food items that are low in nutrients. What is also intriguing here is that these meals still seem to follow the definition of a traditional Marshallese plate. Western European and American foods that have been added to the cadre of food choices decades ago were assigned their symbolic gender in order to place them within the availability of viable food choices. With time, imported foods have become the norm, and, in many cases as highlighted from the interviews, the preference among children for plates.

Grocery Stores and Food Availability

A series of observations in the field and from interviews led me to explore the availability of food on Majuro Atoll through examination of grocery stores. There are two different types of grocery stores located on Majuro Atoll, chain and "bodega" stores. The first type resembles the stereotypical American idea of a grocery store. One of these stores, Formosa, is a chain grocery store with its corporate headquarters located in Taiwan. The Majuro Formosa is located in Uliga. Another chain of grocery stores, K&K Island Pride Supermarket, has a large store located in Delap, directly across the street from the capital building. They have a smaller store located in Rairok but it does not offer as many options for groceries and goods. These three stores offer canned foods, frozen and butchered meats, "fresh" produce, boxes of milk, cheeses, processed foods, fast food, baked goods, general merchandise, and home appliances. A person can also buy wholesale items such as alcohol, sugar, rice, cans of tea and fruit juices, and instant coffee. One observation made from conversations with many Marshallese was that most islanders usually visited these stores for at least one item in particular: rice. A 15 pound bag of rice would cost an individual $8.95 at K&K Island Pride Supermarket as of January 2015. Figure 6.2 displays a picture of rice for sale at a "bodega" located in Uliga. One 20 pound bag of rice, like the one for sale in this picture, will make approximately 43 cups of cooked rice. Figure 6.3 has a picture of what 1 cup of rice looks like. Brown rice is almost never selected by Marshallese. Many Marshallese have commented to the investigator that they did not like the taste of brown rice. This opinion was stated despite Majuro Islanders continually being reminded by the government about the healthier contents of brown rice and the potential occurrence of beri beri, a vitamin (thiamine) deficiency that can occur from a reliance of eating polished white rice (Gladwin 1970). This occurs when polished white rice remains a staple of a person's diet. A number of other Marshallese commented to the investigator that they "simply did not feel full" unless rice was served with their meal. These "supermarkets" require travel to and from as well as the income to purchase goods. The importation of food items, especially when not in bulk form, to the atoll often drives the cost of products to more expensive levels than what

American supermarkets charge. For instance, a box of Honey Nut Cheerios, a favorite of mine, would cost $7.00 in 2008 at one of these supermarkets.

The term “grocery store” is used loosely with the second type of store as they resemble neighborhood “bodegas” operated out of someone’s private property. Figures 6.4 and 6.5 display the shelves of typical items one can find at these “bodegas”. Generally, fresh fish and produce cannot be bought at these stores. Any fish is usually canned and includes tuna in oil, sardines or mackerel canned with some kind of sauce. Cans of SPAM, lunch meat, whole corned beef or hash, and beef stew are the options for meat or protein. Other common items found at most of these “bodegas” include condensed milk, peanut butter, tapioca starch, cooking oil, cookies, snacks and other processed foods. Canned fruit salad and pineapple are usually the fruits available. Sauces such as ketchup, soy sauce, and Tabasco are common to Marshallese tables. Seasoning food as it cooks is not a common occurrence. A plethora of sauces and some spices are usually on the “dinner table” allowing the individual consuming the food to choose how or if they need to season their food. Although a previous picture displayed bags of rice for sale, it is not common for every “bodega” to carry these bulk items. This type of grocery store is located in every community on Majuro and for communities such as Ejit, Ajeltake, Woja, Long Island and many in Laura, they are the only source of potential food for their family. Although breadfruit and pandanus are more commonly grown in these communities, these food items are seasonal as well as often limited to certain families.

Questionnaire Data

I will now turn my attention to the questionnaire (See Appendix I) distributed to the parents of Marshallese children participating in the nutritional assessment. Ninety-six questionnaires were returned by parents from 588 children sampled for a participation rate of 16.3%. This questionnaire was comprised of 29 questions exploring lifestyle factors such as socioeconomic status, household size, parent's education, migration, living arrangements and demographic information for the household. The questionnaire was developed with the use of literature review (Bernard 2002) and recommendations from the Gittelsohn pilot study exploring material style of life (1998). The questionnaire has not been research validated. Despite this issue, the questionnaire responses are still used to explore potential differences between the households of children attending public and private schools. Questionnaire responses were compared using Fisher's Exact Test, Pearson Chi-square, student's t-test, and Mann-Whitney U tests, as appropriate.

Table 6.1 displays the demographic distribution of questionnaires that were returned. The Marshallese sample from the nutritional assessment in this study has similar sex distributions compared to the questionnaires returned for the public school group (Males: 53.6% vs. 55.2%, Females: 46.4% vs. 44.8%). Unfortunately, the same distributions were not seen with the private school group. Only one questionnaire was returned that represented females attending private schools in the 2008-2009 sample. Although a similar sex distribution between the nutritional assessment and questionnaire responses was desirable, this point should not represent discrimination in the findings as the sex of the child should not affect a parent's age, educational level, or income.

Some interesting initial responses involved the communities in which private and public school children reside. The private school children all come from the communities of Uliga, Delap, and Rairok. These should not be confused with the elementary school. Majuro

Cooperative is located in Delap and Assumption is located in Uliga. In the literature review for this dissertation, the reader was introduced to the Marshallese caste system and these included Iroij, Alab, and Rijerbal. It should also be noted that Iroij land on Majuro is located in the communities of Rita, Uliga, Delap, and Rairok. Although Iroij families do own land located in various other locations on Majuro Atoll, their primary residences are located in these communities. A majority of the public school children attended the elementary school located in their community. Another initial interesting finding from the questionnaire was the perceived ethnicity of the child by the parent. Private school parents referred to their child as Marshallese, Marshallese-American, Japanese-American, or Marshallese-American-Japanese-German. One point of emphasis is that all children sampled in the study were "Marshallese" by the standard that one parent was considered Marshallese. The majority of public school parents referred to their child as Marshallese. Other responses given by public school parents included American, Marshallese-Korean, Marshallese-Pacific Islander, Marshallese-German, and American-Japanese-Chinese. Although it was not necessarily the focus and no discernible distinction could be made between public and private school children here, it is interesting to note two points. The first involves the fact that some parents did not identify their child as Marshallese, despite one of the parents being Marshallese. Second, some parents identified a shared or mixed ethnicity. In this way, the ethnicity of both parents, or in some cases, both maternal and paternal grandparents' ethnicity was accounted for in their description of their child.

There were a number of questions asked that found no statistically significant difference between our public and private school children, yet the information revealed by the questionnaire is interesting and of note. First, there was no difference in the distribution of children who were adopted into the home (Fisher's Exact Test, p=1.00). Yet, overall, 22.9% of the returned questionnaires indicated that the participating child was adopted. Generally, if the guardian is not the birth parent, they are usually a family member and this adoption usually occurs in the first year of life (Walsh 1999).

Another non-statistically significant response from public and private school parents involves the highest level of education obtained. There was no statistically significant difference in the distribution of education level among the private and public school parents (Fisher's Exact Test, p=0.258). There may be some sampling bias here as I divided nine private school responses among four potential education levels, but this is why Fisher's Exact Test is used instead of Pearson Chi-Square. No statistically significant differences were discovered when examining "if the child was breastfed" or "the length of breastfeeding" (Fisher's Exact Test, p=0.590 and 0.422). Smoking in the household was also not different between private and public school responses (Fisher's Exact Test, p=0.705).

A summary of vaccination coverage was conducted on Majuro Atoll and Ebeye Island, Kwajalein Atoll in 2006. A cohort of children born in calendar year 2006 was followed for three years. The report from 2009 found that full immunization coverage, which included six immunizations (BCG, HepB, DTP, OPV, HIN, MMR), was only 52.8% on Majuro Atoll (RMI MOH 2009). This low rate of immunization led to an interest in health and hygiene practices and the spread of viruses and bacteria. No significant differences were found between public and private school responses for: "Whether the child had diarrhea, a cold or respiratory infection in the last year" (Fisher's Exact Test, p=0.436) and "The child's hand washing frequency" (Fisher's

Exact Test, p=0.560). Children were still getting sick with some frequency in Majuro, but the questionnaires did not detect any difference by type of school.

Another result of interest involved the question, “From which source does your water come?” These responses were collapsed into whether or not the household had a water catchment/well or not. No significant difference was found among public and private school households (Fisher’s Exact Test, p=0.436). What was surprising is that a majority of public (71.4%) and private (88.9%) school homes did have a water catchment. My initial thought was that water catchments and wells might explain potential growth problems as they provide breeding grounds for water-borne pathogens. A cholera outbreak occurred on Ebeye Island, Kwajalein Atoll in 2000 (Algrehn 2007). One major suspected cause of the outbreak involved unclean water sources, specifically wells and water catchments. With a large population of people living in a close area, human biological and other waste often found pathways into these water sources. An epidemiological study found that the lack of water treatment and using the same containers to collect and store treated and untreated water greatly increased the spread of the Cholera (Algrehn 2007). After living in Majuro, I learned that this is a current and constant fear, but many people still contract water-borne bacteria by not treating their water. A follow-up comparison was completed exploring nutritional and anthropometric measurements between people owning and not owning a water catchment. No statistically significant results were discovered. A further observation of mine is that owning a water catchment could be considered a privilege in the Marshall Islands as they can be quite expensive.

The evidence presented so far does not differentiate the public and private schools, but a number of questionnaire responses did reveal statistically significant differences. Tables 6.2, 6.3, and 6.4 present these results. There was no statistically significant difference in age of the father (Mann-Whitney U=177.0, p=0.107) or mother (Mann-Whitney U=172.0, p=0.154) between public and private school children. The next two questions from Table 6.2 revealed a larger average number of people (Mann-Whitney U=109.50, p=0.001) and children (Mann-Whitney U=120.00, p=0.002) living in the public school households when compared to the private school homes. Public school homes had, as the median suggests, twice as many people living in them when compared to private school homes. Related to this, public school homes had twice as many children as were found in private school homes. One public school home had 20 children noted as living in the home. My statistical results do not include this home as it was considered an extreme outlier. The final question displayed in Table 6.2 explored how many people living in the home had a paying job. Although the median is similar for public and private school homes, the dispersion of data among our two groups was statistically significantly different (Mann-Whitney U=178.00, p=0.035). Therefore, my interpretation here is that generally, public school homes had more people living in them with a paying job.

Table 6.3 compares the private and public school children by where they were born. The questionnaire simply asked “On what island was your child born?” These responses were joined into three categories as I wanted to obtain some perspective on migration of the child from birth. These categories included “RMI: Majuro”, “RMI: Not Majuro”, and “Outside RMI”. In other words, the child was born on Majuro Atoll, on another atoll in the Marshall Islands, or outside the country of the Republic of the Marshall Islands. Another caveat to remember with this analysis is that children included in the 2008-2009 sample had to have at least one

Marshallese parent. The distribution of the public and private school responses revealed that 6 of 9 private school children appear to have been born outside the Marshall Islands.

Table 6.4 examines the income supporting each home. The questionnaire (Question 8) originally offered seven responses for household income, but upon looking at the distribution of responses, a clear line of demarcation could be drawn at the level of $325.00. This new distribution is supported by the fact that a majority of private school homes reported $325.00 a month as income. A statistically significant difference was found with both distributions (Fisher's Exact Tests, p=0.008 and p=0.002). The conclusion is that, generally, a private school home had more monthly income compared to a public school home.

Conclusion

The analysis of the 2008-2009 sample of public and private school children revealed statistically significant differences in nutritional and anthropometric measurements. The questionnaire in this chapter has now displayed social and behavioral differences among public and private school homes. These differences included the average age of the mother, the average number of adults and children residing in the household, how many of these adults have wage paying jobs, the amount of income supporting public and private school homes, and where the Marshallese child was born.

This information, along with what has been discussed about food history, current food habits and food availability, is used in the next chapter along with the results from the previous chapters to discuss the possible connection and reasoning for why differences were seen in the nutritional and anthropometric measurements among public and private school children.

Chapter 6 Tables and Figures

Table 6.1: Demographic Distribution of Questionnaires

Distribution of Questionnaires						
	School Attended	**n**	**%**	**Sex**	**n**	**%**
Private						
	Assumption	4	44.4	Male	8	88.9
	Majuro Cooperative	5	55.6	Female	1	11.1
	Total	9	9.4			
Public						
	Uliga	4	4.6	Male	48	55.2
	Delap	37	42.5	Female	39	44.8
	Laura	14	16.1			
	Rairok	7	8.0			
	Rita	13	14.9			
	Woja	2	2.3			
	Ejit	10	11.6			
	Total	87	90.6			

Table 6.2: Selected Questionnaire Results-Public vs. Private School Children

	Mother's Age					
	n	Median	25th Percentile	75th Percentile	Mann-Whitney U	p
Public	80	34	29	39.75	177.00	0.107
Private	7	38	34	40		
	Father's Age					
	n	Median	25th Percentile	75th Percentile	Mann-Whitney U	p
Public	73	38	32	44	172.00	0.154
Private	7	40	38	52		
	How many people are in your household?					
	n	Median	25th Percentile	75th Percentile	Mann-Whitney U	p
Public	84	8	6	12	109.50	0.001*
Private	8	4	3.25	6.75		
	How many of these people are children?					
	n	Median	25th Percentile	75th Percentile	Mann-Whitney U	p
Public	84	5	3	7	120.00	0.002*
Private	8	2.5	1	3		
	How many people in your household have a paying job?					
	n	Median	25th Percentile	75th Percentile	Mann-Whitney U	p
Public	81	2	2	3	178.00	0.028*
Private	8	1.5	1	2		

*$p < 0.05$, statistically significant

Table 6.3: Where was the child born?

	RMI: Majuro	RMI: Not Majuro	Outside RMI	Pearson Chi-Square	p
Public	73	8	5	25.465	<0.001*
Private	2	1	5		

*p < 0.05, statistically significant

Table 6.4: Income per month supporting the home

	Less than $325 a month	$325 or more a month	p
Public	51	26	0.005*
Private	1	7	

*p < 0.05, statistically significant

Figure 6.1: Pandanus and Breadfruit

Figure 6.2: Rice in "Bodega" Uliga, Campus of College of the Marshall Islands

Figure 6.3: One Cup of Cooked White Rice

Figure 6.4: Grocery "Bodega" Store Picture 1

Figure 6.5: Grocery "Bodega" Store Picture 2

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Chapter 7: Discussion and Conclusion

The pilot study conducted in 2006 was found to have methodological issues and led to the completion of this dissertation. My study attempted to address these methodological issues while also expanding the sample to include all grade levels among primary school children. Two hypotheses were offered in comparing the private and public school children. The first hypothesis stated that there would be no significant difference between the average height-for-age, weight-for-age, and BMI-for-age z-scores when comparing students attending Majuro primary public and private schools. Body composition measurement z-scores would also reveal no significant differences between the two groups as well. The results allowed me to reject this hypothesis as a clear difference was seen between public and private school children in their growth measurements. The second hypothesis stated that each of these groups, public and primary school children, would not statistically significantly differ in their average attained growth measure z-scores when compared to the WHO 2007 reference population. Both public and private school children were found to have growth measures that were statistically significantly lower than the reference mean despite finding private school children "outperforming" public school children in their growth measures.

Recreating this study also allowed me to complete a more recent nutritional assessment of Majuro school children in order to see if malnutrition has improved, remained static, or declined. In this final chapter, I review the results of this nutritional assessment as well as tie together the information I have presented in regards to the public and private school comparison, the household questionnaires, interviews, and historical assessments conducted in the Marshall Islands.

Nutritional Assessment Review

After the completion of the nutritional assessment in this dissertation, some things can be stated about the sample population as a whole. The overall rate of stunting among participants in my sample was 34.6%. In comparison to surveys conducted by Alfred in 1991 and Gittelsohn in 1998, the rates of stunting were similar despite the use of different growth references. The males in my 2008-2009 sample exhibited a lower rate of stunting (31.2%) compared to the female population (38.7%). A z-test for two population proportions did not reveal a statistically significant difference (Z=-1.88, p=0.06), but the p value did approach significance. Although the difference was not statistically significant, it could be argued that there was a clinical difference in the rate of stunting among the sexes. In other words, although the difference in stunting rates was not statistically significantly different, the rate of stunting was higher in females and this could be relevant to the health worker on Majuro Atoll. The difference found in stunting rates among male and female Marshallese children may be due to the use of the WHO 2007 reference. The WHO 207 reference is based upon an American sample. If the onset of puberty occurred earlier in the reference females and if Marshallese females were delayed in their onset of puberty, the early age adolescent females included in my sample may have appeared shorter for their height. This observation conflicts with what Alfred (1991) reported as the average age of menarche among Marshallese females. Alfred (1991) found that the average age of menarche occurred at 12.3 years for Marshallese females with a range of 10-16 years. Alfred (1991) also reported that in developed countries, the range was from 10 to 13 years with an average at 13 years. This range included data collected from American populations, but it also included other populations as well. The age range that Alfred

(1991) presented was 10-16 years. If enough of the Marshallese females in my sample experienced menarche at the later ages of this range, it could explain why more females were considered stunted for their age when compared to the WHO 2007 reference. But, the age at onset of menarche can change within a population over time, and, at the moment, I cannot offer any certain reasoning as to why there was a sex difference exhibited for stunting. This issue should be considered in future research.

Although the WHO 2007 reference only examines weight-for-age in children aged less than ten years, weight-for-age z-scores calculated from my sample revealed a rate of 8.2% of "low weight" in this age category. The rate of "low weight" was actually higher for Marshallese males in my study sample (10.6%) compared to the females (5.6%). A z-test for two populations did not reveal a significant difference ($Z=1.45$, $p=0.15$). The Marshallese children in my sample were experiencing malnutrition acutely, but the rate of malnutrition reflected from weight was not as severe as the chronic malnutrition revealed from the height-for-age indices. This point was illustrated with the WHO 2007 growth curves presented in chapter four (Figures 4.2-4.5) in which average Marshallese height and weight measurements were plotted. Both male and female growth trajectories for height fell just above or along the 3rd percentile line on the growth curves. Similarly, the average weight measurements plotted on the WHO 2007 weight-for-age growth curves revealed both males and females consistently plotted just above the 15th percentile. Both the height and weight measurements among the Marshallese were significantly below the reference mean, but they were more stunted than underweight. This disproportionality caused the calculation of body mass index to appear relatively normal compared to the WHO 2007 reference (Figure 4.6 and 4.7). This point has been discussed previously in the dissertation. The total sample only revealed a rate of half a percent of children being considered “thin” or “underweight” by the reference definition. The calculated body mass indices revealed 9.5% and 2.6% of the total sample population as being overweight and obese, respectively. If one were to examine only the body mass index classification results, one might conclude that Marshallese school children on Majuro were not wasted and might even appear “healthy”. However, the data from height-for-age and weight-for-age should lead the reader to conclude that the classification of 87.4% of the children in my 2008-2009 sample as “normal” weight for their height was inaccurate.

Despite the results for the body mass index-for-age, the data suggests that Marshallese children (ages 5 to 14 years) were experiencing malnutrition acutely and chronically. Gittelsohn (1998) and Gammino (2001) both reported stunting prevalence rates occurring at much higher proportions for the youngest children (0-5 years) in their sample (Table 4.23). A study from 2001 showed that growth faltering can be revealed through anthropometric measurements as early as 3 months of age (Shrimpton et al. 2001). Mean weights can be seen to begin declining at 3 months of age and weights will rapidly decline up to 12 months. The rate of decline slows until 18 to 19 months of age. Usually, malnourished children show a rate of improvement after 18 to 19 months. Height, or more appropriately, length measurements reveal faltering beginning right after birth and can continue through the third year of life (Shrimpton et al 2001). Gammino’s (2001) data found no recovery though, as the proportion of stunting continued to increase in Marshallese children up to the age of five. The relatively steady trend of poor growth outcomes seen when average measurements from Marshallese children in my sample were plotted on the 2007 WHO growth curves suggests that the growth faltering seen here in childhood might have begun in infancy, and possibly in utero. Many children on Majuro are starting off malnourished in infancy and they are never improving.

In contrast to this point, one might consider if there is simply a population-specific genetic difference occurring between Marshall Islanders and the American sample used to construct the WHO 2007 reference. The consistent findings in the rates of stunting among Marshallese youth may reflect genetically-driven growth patterns that were different from the reference populations used to explore nutritional assessment. In chapter 2, Uliajszek (1994) was noted as assessing the differences between genetically-driven and environmentally-driven growth “deficits” in populations from developing countries. Again, Uliajszek (1994) suggests isolating the children from the highest socioeconomic groups within a developing country and examining their growth measures. My study did this with the comparison of public and private school children. Private school children living on Majuro were statistically significantly taller and heavier than the public school children. Private school children were also compared to the WHO 2007 reference and were found to be statistically significantly lower in height and weight. This finding initially leads me to argue that Marshallese Islanders have a genetically-driven growth potential resulting in shorter heights and lower weights compared to the WHO 2007 reference. Despite my argument here, I do believe that both population differences in growth potential and nutritional deficits are present among public and private school children. Even though private school children (the highest socioeconomic status) “outperform” public school children in growth measures, I believe some private school children were still experiencing nutritional deficits. Marshall Islanders appear to be a population that simply has a lower growth potential compared to the WHO 2007 reference, but it also appears that many children living on Majuro are never reaching that potential. This point is explored further with body composition measurements below, and it is also discussed when I return to the comparison between public and private school children below.

The body composition measurements also allow me to generally describe the 2008-2009 sample of Marshallese school children. Overall, the sitting height of Marshallese children revealed a shorter axial skeleton when compared to the WHO 2007 reference. Although this measurement was also affected by malnutrition and other environmental insults, the relatively higher sitting height indices revealed that Marshallese children have a longer axial skeleton compared to their appendicular skeleton. The growth of the long bones in the legs has probably been affected by the chronic insult of malnutrition and other environmental insults (Malina, Bouchard, Bar-Or 2004). This point was especially apparent when attempting to calculate the index “upper arm muscle area by height”. A large number of children could not be compared to the Frisancho (1990) reference because their short height was not represented for their age in the reference data. Elbow breadth measurements also revealed smaller framed skeletons compared to the reference. The conclusion was that Marshallese skeletons are small or extremely small when compared to the Frisancho (1990) reference.

The body fat percentage calculations showed that, as age increased for girls, the amount of body fat also increased. This phenomenon was reversed in the sample of males in my study. As the males increased in age, body fat percentage decreased. This difference was similar when looking at upper arm muscle mass and fat mass. The reader should keep in mind that despite the classification of “average”, the average mid-upper arm circumference and total arm area calculations consistently fell below the reference mean. This point is important because upper arm muscle and fat mass are calculated by taking the area of the arm into account. Marshallese males in my 2008-2009 sample had the classification of “average” muscle mass from age 5 to 10, but 11, 13 and 14 year old male groups were classified as having a “below average” muscle mass. Every age group, except 9 year olds, among the Marshallese females in this sample was described as having an “average” muscle mass. The calculation of upper arm fat area classified Marshallese males and females in my sample as having “average” fat. Taken together, Marshallese children sampled in this study carried more fat to muscle on their arms compared to the Frisancho (1990) reference. The subscapular skinfold compared to the triceps skinfold measurements suggest that more fat was carried on the axial skeleton of Marshallese children. Despite this difference, the sum of skinfolds classified males and females, in all age categories, as having “average” fat compared to the reference. This point is supported by the fact that the majority of subscapular and summed skinfold measurement means for each age category fell above the reference mean. The majority of average triceps skinfold measurements fall below the reference mean.

Again, when body composition z-scores were compared between the private and public school children, private school children “outperformed” public school children in these measurements. Like height and weight, the body composition measurements among private school children were still statistically significantly lower when compared to the WHO 2007 reference. It appears that private school children, representing the highest socioeconomic status on Majuro Atoll, were exhibiting a genetically-driven growth potential different from the population (American) used to construct the WHO 2007 reference.

Environmental Insults

I implicate environmental insults in the causation of widespread malnutrition among Marshallese children. For Majuro Atoll, these environmental insults include nutrition, communicable diseases, and economics, particularly economic disparity or poverty.

Nutrition is listed here as an environmental insult, but there are a number of angles that one can take with the topic of food on Majuro. However, most of these angles relate back to the idea of food availability. Majuro Atoll, as the capital of the country, acts as the major import point for people and goods. Not only does the airport serve as an entry point for people, goods and food, but there are two major docks for large fishing and shipping boats. These boats have led to an increased level of harmful materials (e.g. oil) finding their way into the lagoon, resulting in damage to sea life. Pollution of the lagoon has also increased due to human overpopulation. Twenty-eight thousand people living on 3.96 square miles has led to trash and human waste finding its way into the lagoon and ocean. There is a landfill located in Rairok, but it has difficulty handling the amount of trash that the atoll is producing. Unfortunately, some Marshallese on Majuro Atoll simply discard their trash on the ocean side of the atoll. I took a picture of this occurrence during field work and this can be seen in Figure 7.1. This also has contributed to the loss of sea life. The large number of people inhabiting the atoll has also contributed to overfishing in the lagoon as well. Most of the waters surrounding Rita, Uliga, and Delap, the most populated areas of Majuro Atoll, have very low numbers of fish in the water. If a person wants to fish or spearfish, they have to travel five miles west to Rairok or further to find more abundant fish. The best fishing on Majuro Atoll is only accessible by boat. Most Marshallese cannot afford a boat, let alone the gas to operate a boat. In 2008, a gallon of gas would cost an individual $5.75. Unfortunately, the historical uses of outrigger canoes are not common on Majuro Atoll and this is even true to a lesser extent on the outer atolls today. Pollution and overfishing have caused a dearth of fish around the more populated areas of Majuro and so obtaining fish can be limited to what an islander finds in stores.

Farming is relatively uncommon on Majuro as well. There are two farms located in Laura, on the far Western side of the atoll, but these are fairly recent with the first one originating in 1991. These local vegetables and fruits are usually distributed to the chain grocery stores and "bodegas" for sale throughout the atoll. The price for these vegetables and fruits are not extreme, but not every store carries these items. Some of this food is distributed to households in need, but no data on the amount of this distribution could be discovered while in the field. Usually, the majority of these local fruits include breadfruit, pandanus, banana, and papaya. Breadfruit and pandanus are seasonal fruits and not always available. Beans and tomatoes are usually grown at these farms as well. In the urban areas, farming is a difficult endeavor. Figure 7.2 shows a strip plot of land located in Rita, Majuro Atoll. This picture shows five different homes lined in a row. The land and vegetation are barren. If there are breadfruit or coconut trees on a property, the majority of the people living there probably do not own the land. Recalling my earlier discussions of social structure on the island, only Iroij typically own land and therefore non-Iroij do not "own" the food grown there. The presence of corals in the soils paired with ocean winds make it difficult to grow many vegetable and fruit species. This point also relates to the daylight cycles on Majuro Atoll. It is close enough to the equator that sunrise and sunset are usually centered on a twelve hour period. This static light cycle can disrupt the development of many foreign plant species on Majuro Atoll. Going further, many outer atolls, along with Majuro, are still absent of many local fruits and vegetables due to the strong focus placed on coconuts and copra production. This problem is compounded by the continued rising sea levels and flooding on Majuro Atoll. Although flooding of the atoll would historically occur every eight or ten years, the last ten years have seen an increase of these floods and the subsequent increased salinity in the soil could cause even more damage to plant life not adapted to this environment. This problem is linked by many to the current global climate shift and the problem is likely to get worse.

Majuro fits in the third ecosystem suggested by Naidu et al. (1980) and Pollock (1970) (see above) which is characterized by a low availability of local foods, poor fishing, the presence of large government food programs, overpopulation, a good supply of imported foods, and the availability of cash to buy them. The copra trade and cash economy introduced through colonialism brought imported food items and they were adopted into the symbolism of Marshallese food in order to complete a dish or plate. Most Marshallese living on rural atolls still attempt to use these imported foods as supplements to their diet, but for Marshallese living on Majuro Atoll, imported foods have become the common option. The popular opinion for Marshallese living on Majuro Atoll is that local food, or island food, is still preferred, but it is hard to obtain on a regular basis. These foods are found on the table at holidays and Sunday barbeques, but they do not appear to be a common part of the Majuro diet. As Gammino found in 2001, only a fifth of Majuro households rely on local sources of protein such as pig, chicken, and fish (Gammino 2001). But, most of these households are located in rural parts of Majuro. These rural areas would include communities west of Rairok and, to some extent, Rairok itself.

The problem with applying the definition of this third ecosystem to Majuro Atoll is the idea that cash is available (to some at least) to purchase imported foods. In this case, one can even include local island foods for sale at grocery stores and “bodegas”. The analysis of my sample of public and private school children revealed statistically significant differences in nutritional and anthropometric measurements. My questionnaire has also displayed differences among the public and private school homes. What information found from this questionnaire would possibly offer explanations for these biological differences?

I propose that a likely factor can be gleaned from the significant differences revealed on the questionnaires. To some degree, they all involve the economic status of the household. This common theme is obvious when exploring ‘How many people in your household have a paying job?’ and the income of the child’s home. But, let me explore the commonality of economics to each of the statistically significantly different social characteristics and behaviors here. The number of people in the household, including adults and children, was larger on average in public school homes. Although public school homes, on average, had more people with a paying job, they did not have as much income to support their home. Wage paying jobs are limited on Majuro and many Marshallese get paid the minimum wage, which is $2.00 an hour. The median household income is $14,737 a year. This breaks down to $283.40 a week. Although the median pay does appear to be a potential living wage, this median household income includes only those with a paying job. As was discussed in the literature review, only 43% of the population on Majuro participates in the work force. Public school homes had more demand for supplies including food while also having less income to meet that demand. The fact that private school children were more likely to be born outside the RMI displays either the parent’s choice to have the child born at a hospital outside the country or that the parent chose to move the child to the Marshall Islands. Remember, each child participating in this study had to have at least one Marshallese parent. Either way, the cheapest flight from Majuro to any other adjoining airport was approximately $900.00 one-way. The line of thought here is that if you have an average family of 8 with an average household income of $14,737, how do you feed everyone? A parent will probably make the money stretch as much as possible and buy 20 pound bags of rice for less than ten dollars and canned meats. Chapter 6 displayed photos of “bodegas” that sold cans of SPAM for $2.50, beef stew for $2.75, off-brand SPAM for $1.95, and sardines for $0.65. A parent will probably choose these low-cost items in order to build a proper meal that feeds the entire household. The evidence from the questionnaire has shown that private school kids had wealthier parents with less demand on resources. The result is that private school children would have had better access or availability to food and nutrition, which would include healthier and more expensive food options for the household. The economic structure currently in place on Majuro has led to disparity between public and private school homes and this difference is reflected in the difference of growth measures among the two groups.

Thus it would appear that there is an intertwining of food habits and food availability, lifestyle, economic status and the growth and development of Marshallese children. Public and private school homes differ in economic status and this, paired with access to resources, may serve to illuminate the differences in biologic growth evident between the two groups of children. Naturally grown Marshallese food staples are not commonly available to many Marshallese homes on Majuro, although, they may be available in certain areas or stores on

Majuro. Furthermore, the amount of time and cost needed to obtain these items limit access to the average Marshallese Islander on Majuro. In many ways, the combination of availability and cost of quality meats and fish, vegetables, high fiber foods, and fruits creates what in many urban areas is described as a kind of food desert. Children growing up in a public school home only have minimal and sporadic access to these foods and they are not regularly included in their diet. Even when access is available, as is the case with many of our private school children, imported foods are commonly preferred. Common dietary trends tend to display meals representing the traditional Marshallese plate (e.g., a staple paired with a complement or land food paired with a sea or air food) and these imported foods are selected for the creation of these plates.

This kind of limited diet, in which imported foods were selected for consumption or relied upon for sustenance, has been shown to have biological effects in other studies. A study completed by Palafox et al. in 2003 examined the co-occurrence of vitamin A deficiency, iron deficiency, and anemia among young children in the Republic of the Marshall Islands. Nine different atolls were surveyed with 243 children surveyed from Majuro. These children, ranging in age from 1 to 5 years, had an anemia rate of 35.7%, a vitamin A deficiency rate of 63.3%, and an iron deficiency rate of 47.4% (Palafox et al. 2003). Foods such as breadfruit, banana, taro, yams, sweet potato, coconut, fish, red meats, and poultry are all island foods that are rich in vitamin A and iron. But, as discovered in my interviews and participant observation, these foods were not regularly consumed or available. A nutrient such as Vitamin A has been shown in animal experiments and observational studies on humans to have a fundamental role in physical growth (Villamor et al. 2002). A clinical trial conducted with 687 Tanzanian children aged 6 months to five years found that vitamin A supplements had a positive effect on height or length-for-age and weight-for-age measurements (Villamor et al. 2002). Vitamin A down regulates inflammatory responses in humans and can have a major impact in protecting a person against malaria and other diarrheal infections (Villamor et al. 2002). Persistent diarrhea can lead to acute and chronic malnutrition due to the loss of water, electrolytes and other nutrients that were not absorbed in the digestion process (Moore 2010). Another example of Marshallese diet leading to health issues is the reliance on white rice. White rice is processed in the sense that the husk has been removed and the rice kernel has been polished or bleached to extend the shelf life of the product. This process essentially removes any nutrient value of the rice, specifically in this case vitamin B1 or thiamine. Vitamin B1 is involved in carbohydrate, amino acid and lipid metabolism as well as the production of neurotransmitters. Populations (such as the Marshallese) who are dependent on white rice, often have a higher rate of vitamin B1 deficiency which leads to a disease known as beri beri. Beri beri often involves vomiting, neuromuscular problems, weight loss, diarrhea, and edema (Hirsch and Parrott 2012, Sechi and Serra 2007).

One issue first discussed in chapter 5 involved the statistically significant differences between children attending Majuro Cooperative and Assumption, both private schools. This issue was compounded by the fact that I saw children from Assumption only differing statistically from public school children in height-for-age z-scores. Height is a chronic measure of growth, whereas weight and fat mass are more acute in their timing as they relate to the nutritional status of the child. Although the children attending Assumption only differ significantly in height, it is my opinion that this measurement was still a distinguishing factor from the rest of the public school children. Because a majority of children attending Assumption could be assumed to be classified with a private school lifestyle, they would have more frequent access to nutrient rich and higher quality food options. This point was reflected in the overall taller status of these children compared to public school children. But, what was being seen in the differences when comparing Majuro Cooperative and Assumption children? As previously stated, a large majority of children attending Majuro Cooperative either have one American parent or they originate from an Iroij or Alab family status. Iroij, and to a lesser extent Alabs, are the primary recipients of money paid by the United States for the use of Marshallese land. The Compact of Free Association allows the U.S. government to maintain military installations on Kwajalein and other atolls, such as Majuro. The monies paid for the use of this land regularly equates to hundreds of thousands of dollars on an annual basis. The influx of money into the Iroij and Alab family clans with the Compact of Free Association is not a new phenomenon as it is evidenced by the ossification of the caste systems associated with the German copra trade. The old ways of Marshallese culture favored the equal distribution of resources, but the effect of globalization allowed these Iroij and Alab clans to accumulate wealth throughout the twentieth century.

The impact of genetic admixture on potential growth probably has been a contributing factor in the 'outperformance' of growth measurements among Majuro Cooperative children. Yet, as the questionnaire and historical literature reviewed in this dissertation reveals, admixture has been occurring with Marshallese since the late 19th century. There has been admixture among Marshallese from Germans, Japanese, Americans, Chinese, and other Pacific Islanders. So, to simply consider this American admixture as the primary explanation for the growth differences found in this study cannot be supported. I did not record specific information with each child that would allow me to discern whether admixture, or whether the child had a parent that was not Marshallese. For instance, it would have been beneficial to know if children attending private schools more frequently had a parent who was American or Japanese. It is probable that these children more often attend private schools on Majuro, but I cannot say for certain with the results. Future research on Marshallese growth may want to consider this variable when assessing growth.

The presence of an American parent in a household probably establishes an already familiar way of navigating a cash economy and designing a plate based upon nutrient needs. This point is also probably true among the Iroij and Alab family lineages as well as the Marshallese who get the opportunity for higher education and direction in "healthy nutrition". Children from these families have the most access to foodstuffs through the economic status of their families. All private schools on Majuro Atoll offer a school lunch and, in some cases, a breakfast. The impetus for the pilot study that led to this dissertation project was to support the need for a school lunch program for public schools on Majuro Atoll. Public school children are allowed to go home for lunch and many do travel home to get food. Yet, I also noticed during the data collection period that many public school children used their lunch hour to play or would simply leave the school grounds and visit a "bodega" to obtain snacks or candy. Many of these items are sold for $0.50 or less at these "bodegas". So, a child whose family can afford to send them to a private school simply already has more access to food due to the school lunch program present.

The effects of differential food availability can also be seen subtly among the public school children. Post-hoc tests revealed statistically significantly higher amounts of arm fat among public school children living in Uliga and Delap when compared to Ejit or Laura. These tests also revealed larger skinfold measurements among children from Delap when compared to Laura or Ejit. Laura, Woja, Ajeltake and Ejit are some of the more difficult areas of the atoll to access as they require an expensive taxi ride or, in the case of Ejit, a boat ride to get there. Only "bodegas" are located in these communities and so imported foods are still commonly used in the overall diet. But, people living in these rural areas of Majuro would not have as much access to higher fat and calorie-rich imported food items. This point is probably why public school children living in the urban areas, such as Delap, Uliga, and Rita, have larger average amounts of fat deposition.

The United States is currently dealing with malnutrition issues in the form of obesity. The highest rates of obesity have been found among American populations that have the highest poverty rates and the least education (Mendez-Luck et al. 2015, Zhang et al. 2014, Lioret et al. 2014, Drewnowski 2004). Drewnowski conducted a study in 2004 exploring the connection between obesity and the low cost of energy-dense foods. This researcher found that there was an inverse relationship between energy dense foods, defined as energy per unit weight, and energy cost, defined as dollars per kilocalorie. He found that diets based on refined grains, added sugars, and added fats were "more affordable than the recommended diets including lean meats, fish, fresh vegetables, and fruit. The taste and convenience of added sugars and added fats can also skew food choices (Drewnowski 2004: 154)." Drewnowski (2004) argues that the cause of malnutrition was to a larger extent an economic issue as opposed to a lifestyle choice. This same principle applies to Marshallese children, but the major outcome is undernutrition and stunting. The current state of economics among Marshallese families is the acting barrier to proper nutrition and growth. Marshallese children might exhibit higher rates of overweight and obesity if they were able to consume larger amounts of these energy dense foods. Yet, most Marshallese families simply cannot afford the amount or level of consumed energy dense foods that low socioeconomic Americans eat. There is some evidence of this occurring with another Pacific Island population. In 2001, a questionnaire was distributed among Tongans exploring food-related issues such as preferences, perceived nutritional value, and the frequency of consumed local and imported food items (Evans et al. 2001). Tongans, like the Marshallese, have seen increases in malnutrition among their children and adults. In order to address these malnutrition issues, large education programs were designed to encourage lifestyle changes and diet. Yet, the results from their survey show that the consumption of health-compromising imported foods was not related to either preference or perceptions of nutritional value. Instead, Tongans discussed the availability of cheap imports as a major reason to include them into their household diet. More energy-rich foods could be obtained to feed their households (Evans et al. 2001).

The barriers to food described here may be situationally unique to Marshallese living on Majuro through history and economics. But, the pattern of growth faltering seen among Marshallese children has been described before in other developing countries. This growth faltering is suggested to be influenced by nutrition-infection interactions (Scrimshaw et al 1968), with immunological status (Ulijaszek 1998) and with gut permeability, the ability to properly digest and utilize foods (Lunn 2000), playing supporting roles. The literature review in this dissertation suggested that immunization rates on Majuro have been poor with only 52.8% of children getting completely immunized. Cholera and Typhoid are still very present in the Marshall Islands. The study by Hughes et al. (2004) that explored helminthes infections among school children from Laura and Rita found an overall rate of 44.1% infection among the children sampled. The combination of food barriers, infection, and low immunity has all led to environmental insults on the growth of Marshallese school children living on Majuro.

Nutrition Transitions, Modernization, and Developmental Origins of Well-Being

The suggested explanations here are not novel. Previous studies have drawn conclusions between nutrition transition, economics, and growth and development. A study conducted in a rural area of Zimbabwe highlights the interaction of poor farming conditions and prevalent malnourishment (Olivieri et al 2007). Children in this study, aged 6-17 years of age were assessed for height, weight and body mass index. When they were compared to American references, the Zimbabwean boys' height and weight dropped as low as the 10th percentile in some age groups and showed no sign of catch-up growth during the mid-teens. Zimbabwean girls' height and weight were not as low, but did drop as low as the 25th percentile. Yet, catch-up growth did occur during the mid-teens and the girls 'average was close to the 50th percentile by age 16 and 17 (Olivieri et al 2007). The adverse socioeconomic environment and the low levels of food availability compromised and probably delayed the physical development of the affected children in all phases of growth. The authors of this study suggest that lower than average size at early ages could be due to an adaptive mechanism reacting to low food intake. This point is possibly reflected in our Marshallese sample as well. King and Mascie-Taylor (2002) examined the relationship of socioeconomic status and cash cropping to the nutritional state of children living in Papua New Guinea. Malnutrition was prevalent in the child population, but, interestingly, they found educated, bilingual parents had children with better z-scores. Baker and Hanna (1986) have investigated effects of modernization and migration upon Samoans living in Western Samoa, American Samoa, and Hawaii. Slow reversal in the prevalence of communicable to non-communicable diseases, as well as increasing rates of obesity and high blood pressure among Samoan children were observed as modernization increased (Baker and Hanna 1986). This movement towards a modernized society has been discussed many times in populations which are transitioning from a "traditional" diet to one that is very different in nutrient composition (Piperata 2007, Ulijaszek 2005, Cavalli-Sforza et al. 1996, Hezel 1995, Conye 1984, Thaman 1982, Hankin and Dickinson 1972). For Marshall Islanders, this transition has been occurring for more than 150 years. The adoption of a cash economy where cash is irregular appears to be solidifying a reliance on imported foods. So, what has been seen among Marshall Islanders is difficult to label as "transitioning". With the adoption of a cash economy and the rarity of locally grown foods and cash, Marshall Islands children on Majuro are only familiar with the diet that is currently present and available to them.

This phenomenon is not only unique to developing countries. A study conducted in Prince George, a city located in the central interior of British Columbia, Canada, examined body mass index classifications among four neighborhoods differing in socioeconomic status (Lazenby et al. 2007). The researchers predicted an inverse relationship between rates of overweight and obesity and socioeconomic status. Two hundred eighty-three children, ranging in age from six to fourteen, were included in the study. Reviewing social determinant variables, they were able to appropriately describe differences in socioeconomic status among the four neighborhoods. The neighborhood with the lowest income had more single parent families, higher population, and a greater number of the population living below the poverty line. This neighborhood also had the highest rates of undernutrition and obesity out of the four schools surveyed from each neighborhood. The more affluent neighborhoods still had concerns regarding the rates of malnutrition, but their rates were nowhere near the rates found in the neighborhood with the lowest socioeconomic status. Parents from this neighborhood were defined as disadvantaged based upon principles of poverty, ethnicity, parental status, and education. These results were also similar to a study by Moffat et al. (2005) and point to socially determinant interactions of socioeconomic status, food security and gender. The parallel between these studies and our Marshallese sample is that when people are limited in their choices of foodstuffs because of their socioeconomic status, any food that is affordable is consumed. Humans can be overweight or obese and still be malnourished in the sense that they are obtaining the calories they need, but they are not obtaining essential micronutrients for the body to function properly.

Populations experiencing this nutritional transition are also seeing a high prevalence of dual malnutrition occurring in homes where the parents of undernourished children are found to be obese (Angeles-Agdeppa 2003; Delisle and Delisle 2005; Doak 2005). Gittelsohn's work from 1998 found that having a lower economic status appeared to be associated with increased rates of overweight and obesity in urban areas among young and middle-aged adults. This pattern was not seen in the remote areas sampled. What may be occurring among Marshall Islanders are Barker's concepts of developmental origins of chronic disease (2012) and well-being (2004). The beginnings of this phenomenon can start in utero, infancy, or even childhood.

Dual Malnutrition has been documented in developed countries such as Russia, China, and Brazil (Doak 2002; Doak 2000) where most of these families were described as having low socioeconomic status and living in urban areas. Yet, dual malnutrition is beginning to be noticed in developing countries and rural areas such as Mexico, Malaysia and Palau as well (Barquera 2007; Pobocik 2000; Sharif 2003). Increased adiposity, high rates of type II diabetes mellitus and heart disease are well-established consequences of modernization in the Pacific (Cavalli-Sforza et al. 1996).

Obesity related diseases such as these have also increased in Marshall Island adults as well (Gittelsohn 1998). Both Gittelsohn (1998) and Alfred (1991) noted widespread undernutrition among infants and children while epidemic rates of obesity related diseases were prevalent among Marshallese adults. Furthermore, if a child is not receiving the total amount of energy and nutrients he or she needs to complete the full growth trajectory set forth in their hereditary composition, the phenotypic plasticity of the child will develop to the extent with what they have. This child's metabolism, anatomy, and physiology may be permanently altered during the fetal, infant, childhood and adolescent periods of growth and development (Kuzawa 2005; Li 1998; Lummaa 2003). Future and long term research comparing average and malnourished Marshallese children and their parents may reveal the occurrence of this phenomenon. Children experiencing this type of developmental plasticity as a response to severe malnutrition may grow up being biologically programmed to handle lower amounts of energy consumption. Research with undernourished peoples of poor nations suggests the consequences of childhood malnutrition are reduced adult body size, impaired work capacity throughout life, delays and permanent deficit in cognitive development, and impaired school performance (Pelto and Pelto 1989). As adults, an overabundance of calories and fat could lead to a higher propensity for developing non-communicable diseases such as type II diabetes, hypertension, cardiovascular disease and cancer (Osmond 2000).

Recommended Intervention for the Marshall Islands

In 2006, Gittelsohn et al. published a plan to develop and implement a food store-based intervention to improve diet in the Republic of the Marshall Islands with the particular emphasis on Majuro Atoll. Their hope was to work with local store owners in an attempt to get them to stock their shelves with more healthy food options. The plan involved promotional activities at stores including demonstrations on how to prepare and cook healthy food items that many on Majuro were not used to purchasing. Taste tests were also offered at these promotional activities.

Interviews were conducted with small and large stores on Majuro during the development of this intervention. The store owners stated that the most profitable foods in their stores were poultry, beef, fresh fish, eggs, butter, and cereals. The least profitable foods were rice, fruits, and vegetables. Fresh produce does attract customers but these items have a high rate of spoilage (Gittelsohn et al. 2006). Many store owners mentioned that they felt the Ministry of Health should assist and support the stores with the effort to implement the program. Yet, many store owners expressed a commitment to promoting healthy foods as long as they sold. Some stores were even willing to take an initial financial risk by ordering new products and carrying a small amount of them. Essentially, one store manager summed up the situation by saying, “If people buy, we sell it. If they stop, we don’t sell it” (Gittelsohn et al. 2006:400).

Although the results of this intervention have yet to published, I do not think that this intervention challenges the problem well enough. It isn't enough to get stores to agree to carry healthy food items. The economic scheme of Marshallese on Majuro defines the availability of healthy food. If people cannot afford healthy food, they are not going to buy it on a regular basis and the availability would diminish again. As was discussed earlier in Tonga, just because healthy food options are available does not mean they are accessible.

A plan was drafted in 2008 by the Republic of the Marshall Islands Ministry of Health to address non-communicable disease and nutrition issues. This plan, The Non-Communicable Disease/Nutrition Strategy 2008-2012, reported on overall statistics of Marshall Islanders from 2002. The data presented in Table 7.1 included individuals aged 15 to 64 years. Late adolescents and adults surveyed for this report ate fruits and vegetables less than three days a week. Going further, even when fruits and vegetables were consumed, 91% of these individuals did not consume the suggested servings on a regular basis. Turning towards the body mass index presented for males and females, a large proportion of the late teenager and adult population was overweight or obese. As mentioned before, the coexistence of obesity and undernutrition exists within Marshallese families and communities. What the report does not specifically discuss, though, is the issue of availability and affordability of these food stuffs. The strategy outlined different avenues leading to increasing good nutrition among Marshallese Islanders, including plans on national, sub-national, work place, school, and individual levels. These plans involved education, government and school policies, establishing home gardens, working with store owners near schools and limiting children’s access to poor nutritional choices, and providing a school lunch program. Unfortunately, there was no money budgeted into the plan to provide school lunches. The recent increase in flooding also leads me to consider the use of home gardens among Marshallese as a difficult endeavor as well.

Again, this strategy does not consider the impact of economics on food choice and availability. I argue that the common idea among current proposed nutrition interventions is that Marshallese Islanders are ignorant in proper nutrition and have a choice in what they consume. For many of those living on Majuro, the knowledge of healthy choices in food exists but the economic scheme has limited this choice. I think that policies or endeavors such as these do not tackle the true problem with malnutrition in Majuro. Instead of localized efforts to instruct Marshallese on proper nutrition or attempting to make certain foods available in stores, efforts need to be directed at providing children with these resources. For instance, funding should be directed at a school lunch program for children attending public schools. All of the national, sub-national, and work place plans do not specifically address the individual. Unless the economic scheme currently present in Majuro changes, efforts should be made to focus on the individual, especially children.

Future Research Directions

This dissertation project was built upon the previous work of Joel Gittelsohn (1998), Victoria Gammino (2001), Julia Alfred and Neal A. Palafox (1991). Technically, this dissertation is the largest nutritional and anthropometric assessment of Marshallese children ever conducted. Part of this direction was guided by the literature and email conversations with Joel Gittelsohn and Victoria Gammino. His pilot study (Gittelsohn 1998) identified a number of directions to explore malnutrition in the Marshall Islands. In particular, one thing that Gittelsohn explored in his pilot study was the juxtaposition of growth on urban and rural atolls. This dissertation raises an issue with this classification. Describing children or lumping them together due to urbanness or ruralness does not do justice in representing the variance of growth in children living on Majuro or elsewhere. Even within Majuro Atoll, differences in growth, diet and lifestyle were observed. One truly has to take into account social factors and behaviors such as economics, socioeconomic status and food choice/dietary habits within these urban or rural atolls. It is understood that this variation was also present within this dissertation's classification of "private school children" when statistically significant differences in growth measures and indices were found between Assumption and Majuro Cooperative schools. Understanding the potential variation within the defined study populations should always accompany completed growth and nutritional assessments.

Victoria Gammino, a student of Gittelsohn, explored the health and growth of children living on Majuro and rural atolls aged from birth up to five years of age. This dissertation built on this previous research by exploring children aged 5 to 14 years of age, but solely on Majuro. Future research will attempt a collaborative approach to constructing a population-specific growth chart of Marshallese children. An issue with the WHO 2007 reference is that it does not account for population variation around the world, specifically, the Pacific region. As Bogin stated, ''hereditary and environmental determinants affect the growth and development of people around the world and this effect has an outcome on the accuracy and reliability of the research that health care professionals conduct with the people they serve" (Bogin 1998: 263). Bogin (1998) also stated that humans living today adapt their body size to the conditions in which they live. A smaller or larger average body size may be found in the Marshallese population regardless of the presence of malnutrition. Yet, the results from this dissertation found that private school children, who represent the highest socioeconomic families on Majuro, had growth measures statistically significantly lower when compared to the WHO 2007 reference. It is for this reason that a population-specific growth chart for the Marshallese should be constructed using children growing in the healthiest local environment. A population-specific growth chart is critical to verify similarities or differences found in the growth trajectory of the Marshallese children when compared to these reference populations. This dissertation project begins the process of creating this population-specific growth chart.

One result of this dissertation project, unfortunately, was the recognition that malnutrition was not improving among Marshallese living on Majuro. I cannot make a suggestion that Marshallese simply need to increase the number of wage paying jobs or the distribution of money in an attempt to provide better access to food and nutrition. But, a number of Marshallese are relocating to the United States, especially Hawaii, California, Washington, Oklahoma and Arkansas. Marshallese Islanders have free access to the United States without a visa as dictated by the Compact of Free Association. The Compact also allows Marshallese to participate in social aid programs such as welfare and Medicaid. I would like to examine the growth and development of Marshallese children and adults in these locations where wage paying jobs are available along with social welfare programs. Such a study could mirror that of Bogin (1999) appropriately titled, *Maya In Disney Land*. The question should be asked, "What kind of choices do Marshallese make in terms of the food they select when economic barriers are improved or removed?"

A final concept that should be addressed concerning Marshallese growth is the period before infancy, in utero. As Barker has suggested in his 2004 and 2012 papers, the development of chronic disease may actually begin while still in the womb. Supporting this kind of hypothesis would require a mixed study design employing both cross-sectional and longitudinal growth measures at all phases of growth, including ultrasound growth measurements in utero. Before leaving Majuro Atoll, I obtained a de-identified birth weight data file including over 40,000 Marshallese dating back to 1923. This type of data may prove useful to a study exploring in utero growth and birth weight of Marshall Islanders. As stated in the literature review of this dissertation, the Republic of the Marshall Islands has one of the largest infant mortality rates in the world. Much of this mortality rate as well as growth faltering in children may be linked back to a lack of prenatal care in the Marshall Islands. If so, potential intervention programs, supported perhaps by visiting Ob/Gyn and Family Medicine physicians, may help initiate a change in mortality rates, growth faltering, and possibly non-communicable diseases.

It is my hope that the results of my research will provide an additional impetus leading to changes in these areas of concern. I also hope that expanding this research in the future will be able to demonstrate improvements in all three areas.

Chapter 7 Tables and Figures

Table 7.1: Non-Communicable Disease/Nutrition Strategy 2008-2012, 2002 Reported Data

Mean number of fruits consumed (days/week)	2.6	
Mean number of vegetables consumed (days/week)	2.7	
Percent who ate less than 5 of combined servings of fruit and vegetables per day	91	
	Males	**Females**
Mean BMI	26.7	28.5
Percent Overweight or Obese	59.8	65.4
Percent Obese	31.6	26.6

Figure 7.1: A Picture of the Ocean Side of Uliga, Majuro Atoll

Figure 7.2: A Strip Plot of Land Located in Rita, Majuro Atoll

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Appendices

Appendix A: Letter of Intent

To the government and community officials of the Republic of the Marshall Islands,

Hello, my name is Todd Foster and I am a graduate student in the department of Anthropology at Indiana University. I am writing you today to discuss the possibility of completing a research project on the atoll of Majuro. In this letter, I want to begin by briefly discussing the intentions of the project. I then will discuss my visit to Majuro in the summer of 2006 and the work in which I participated. The letter will conclude with further explanation of what this project could provide for the Republic of the Marshall Islands, why I feel the need to return to the Marshall Islands to complete research, and what I am asking for in terms of guidance and support from the ministries of Health and Education.

The study that I am proposing for the Republic of the Marshall Islands is the beginning of a long-term project that aims to explore the growth and development of the population. Specifically, I would like to develop growth charts that are population specific. In the past, when any examination of malnutrition, undernutrition or obesity, has occurred with researchers or pediatricians, they were comparing Marshallese children to growth charts that show the growth trajectory of children living in the United States. The issue here is that many children are displayed as stunted or overweight because Marshall Islanders are being compared to a population that is different from their own. Human populations differ in their physical variation around the world and this variation is caused by numerous factors such as the environment, diet, lifestyle and physical activity, etc. One of the major questions to be addressed with this project is to see whether or not Marshall Islanders follow the same growth trajectory as other reference populations. If they do not, the estimations of malnutrition may have been overestimated in the past. Building a population specific growth chart will also allow for an updated exploration into the health of the children living in the Republic of the Marshall Islands. The last nutritional study completed in the Marshall Islands was conducted almost ten years ago and this project will allow for an updated assessment of the growth and development of the children living in the country.

Before going farther in the explanation of the study, I feel it is important to discuss my past experience in the Republic of the Marshall Islands and the activities in which I participated. I first took interest in the Marshall Islands as a student learning about island nations in the Pacific. I read works from Robert Kiste, Franz Hezel, Larry Carucci and Holly Barker. I was horrified learning about the nuclear and military activities my government, the United States, had participated in throughout the region. As a bioanthropology student looking to make a contribution to people with my research instead of completing research for research sake, I applied for grant money to come to the Republic of the Marshall Islands in order to see what contribution I could make to the Marshallese people. I was awarded money with the premise that I was going to come and look at the feasibility of conducting research in the Marshall Islands. The project I originally was interested in completing was examining the long-term effect of nuclear fallout in the growth and development of children in the Marshall Islands. I arrived in the Marshall Islands in May of 2006 and took a job with the Ministry of Education as a teacher for the English Language Institute. Throughout the first month, I learned from talking with teachers, community leaders, and other Marshallese public figures, that I really needed to stop thinking about what my perceived contribution could be and instead, complete a project that was wanted and needed by the Marshallese people. After my work with the English Language Institute concluded, I took a volunteer position working with the Diabetes Wellness Center as an assistant physical education instructor and collecting data for Dr. Ralph Harris. During this time, I began to meet with other individuals at the Ministry of Health and the Ministry of Education discussing what they felt they had a need for in the country. One of the more influential meetings I was allowed to attend was the Young Professionals Conference, or more accurately, Antoone 2020. It is here that I met many researchers and professionals who discussed current and pressing issues in the Republic of the Marshall Islands. During the conference, I was given the opportunity to join a school lunch committee made up of researchers and business people from around the Majuro community. It was the goal of the committee to see what could be done to get a school lunch program initiated in the public schools on Majuro. With this committee, I helped create a pilot study that examined the difference in growth between public and private school children. Using the data collected by workers at the Ministry of Health, the committee found that there was a significant difference in the height-for-age and weight-for-age among children attending the private and public schools on Majuro. With this previous work, the discussions I had with many of you, and the request for this type of research, I have decided that I would like to come back to the Marshall Islands and complete research examining the nutrition and health of the children in the RMI.

It is from this pilot project that the proposed project has developed. The pilot project completed by the school lunch committee had only compared children from the fourth grade and I would like to expand the pilot study into looking at the full spectrum of children attending schools in Majuro. By taking relatively non-invasive anthropometric measurements on children, we can build population specific growth charts, complete an updated nutritional survey, and examining the effect of the diet in children from birth to 18 years of age. With this statement, it is intended to use nutritional epidemiology in order to examine diet among children. I am hoping to work with nutritionists at the Ministry of Health in completing this portion of the examination as well as teach Marshallese researchers how to take anthropometric measurements so that research can continue without me if needed. I plan to return to the Republic of the Marshall Islands in the middle of May and set up the project over the months of

June and July. I would begin collecting data in August and plan to collect data until the following month of May 2009.

This project is intended to be used as a springboard in developing a long term examination of the health, growth and development of the Marshallese. Eventually, I would like to collect data from children on other atolls in an attempt to compare 'modernized' atolls to the atolls with individuals using 'traditional' subsistence patterns. As far as I know, there is no data that presently shows growth, health, and diet differences between atolls. The closest thing I have found is the pilot research completed by Joel Gittlesohn in 2001. Going further, in recent decades, the Marshall Islands has seen a large increase in the onset of type II diabetes, cancers, heart disease and other non-communicable diseases. By beginning to examine the children of a population, one can then have a better understanding of how adults are handling the onset of these diseases. There is health research in the last decade that suggests the onset of these diseases is programmed for in early life and finally come to fruition later into adulthood. Furthermore, having population specific growth and nutrition data can be used for later comparison in examining whether intervention programs designed by the Ministry of Health have had a positive impact.

I have recently finished my master's degree at Indiana University and I have been trained in bioanthropology, anthropometrics, nutritional epidemiology, and human anatomy and physiology. I have also completed some of my degree requirements in medical science as well as learned advanced multivariate statistical tests. I have been well-trained and feel confident that I can conduct a project of this magnitude with respect and confidence. The program that I entered at Indiana University is a PhD track and I am now at the phase where I am attempting to complete my PhD dissertation work. As I have entered this phase of my education, I had no question where I would like to complete my dissertation research. The Republic of the Marshall Islands endeared itself to me and the people were amazing. I still am in contact with many individuals from the Republic of the Marshall Islands and it is a place where I could see myself conducting long term research for what could be my career as a bioanthropologist… that is, as long as people view me as an asset to the country.

This letter stands as many things. First and foremost, I am looking to see if the Republic of the Marshall Islands is interested in my return to complete such a project. I want to be especially sure that the Ministries of Health and Education would want to work with me on collecting data and building a long standing research relationship. I would be collecting a majority of the data, but I would be looking for access to collecting data in schools from the Majuro community. I would also possibly need letters of intention for entering the community to collect further anthropometric data. Second, I have opportunities to complete this type of research in other areas of the world, but, as already stated, I want to return to the Marshall

Islands because of my previous experience. I want you to understand that my intentions are pure and that I am not just another American attempting to exploit the Marshallese. I have too many friends from the Marshalls to ever want to be perceived in that fashion. Therefore, it is important to have blessings of the Marshallese before I even consider coming to conduct research in the Republic of the Marshall Islands. Finally, I am writing this request for support because I am about to begin applying for funding to complete such a project. I am planning on applying to the National Science Foundation, the Ford Foundation, and the Wenner-Gren Foundation. Having letters of support from the Ministries of Education and Health are pinnacle in showing that the research is wanted and needed. If I am not successful with funding, I plan to still conduct the research on my own, possibly attempting to get a job in the Republic of the Marshall Islands and collecting data during my free time. That is how committed I am to working in the Marshall Islands.

Many of the people I am sending this letter have shook my hand in the past and hopefully many of you remember me because it is in talking with you that I have developed this project. If you have any questions about my roles in the community, further explanation of the developing project, or any general question, please feel free to contact me. My contact information can be found at the end of the letter. The road to getting this project off the ground is extensive involving human subjects clearance, ensuring ethical and appropriate research techniques, getting permissions to conduct the research, obtaining funding to allow the research to be conducted, and other structural properties to ensure a well-conducted project. It begins here though and I look forward to your comments, concerns and questions regarding such a project. A full research design and protocol can be obtained on request and I am happy to provide other documents showing my credentials. Thank you for taking the time to read my statement and I hope to hear from you.

Sincerely,

Todd Foster

Bioanthropology Graduate Student, Indiana University

tlfoster@indiana.edu

804 South Woodlawn Avenue

Bloomington, Indiana 47401, United States of America

United States Phone number: 317-410-3395

Appendix B: Indiana University IRB Approval Letter

INDIANA UNIVERSITY

OFFICE OF RESEARCH ADMINISTRATION

To: Todd L. Foster
Anthropology

From: IUB Human Subjects Office
Office of Research Administration – Indiana University

Date: January 7, 2009

RE: PROTOCOL APPROVAL – EXPEDITED
Protocol Title: Nutritional and Anthropometric Assessment of Marshallese School Children
Protocol #: 08-13511
Sponsor: National Science Foundation

The above-referenced protocol was reviewed by the IRB. The protocol meets the requirements for expedited review pursuant to §46.110, Category 4 & 7. The protocol is approved for a period of **Jan 7 2009** through **Jan 6 2010**. This approval does not replace any departmental or other approvals that may be required.

If you submitted and/or are required to provide participants with an informed consent document, study information sheet, or other documentation, a copy of the approved stamped document is enclosed and must be used.

As the principal investigator (or faculty sponsor in the case of a student protocol) of this study, you assume the following responsibilities:

1. **CONTINUING REVIEW:** Federal regulations require that all research be reviewed at least annually. You may receive a "Continuation Renewal Reminder" approximately two months prior to the expiration date; however, it is the Principal Investigator's responsibility to obtain continued approval from the IRB ***before*** **Jan 7 2010**. If the IRB does not grant continued approval by this date, the study will automatically expire, requiring all research activities, including enrollment of new participants, interaction and intervention with current participants, and analysis of identified data to stop.

2. **AMENDMENTS: Any** proposed changes to the research study must be reported to the IRB prior to implementation. Only after approval has been granted by the IRB can these changes be implemented. An amendment form can be obtained at http://research.iu.edu/rschcomp/instruct.html.

3. **ADVERTISEMENTS:** Only IRB-approved advertisements may be used to recruit participants for the study. If you submitted an advertisement with your study submission, an approved stamped copy is provided with the approval. To request approval of an advertisement in the future, please submit an amendment, explaining the mode of communication and information to be contained in the advertisement.

4. **COMPLETION:** Prompt notification must be made to the IRB when the study is completed (i.e. there is no further subject enrollment, no further interaction or intervention with current participants, including follow-up, and no further analysis of identified data). To notify the IRB of study closure, please obtain a close-out form at http://research.iu.edu/rschcomp/instruct.html.

5. **LEAVING THE INSTITUTION:** The IRB must be notified of the disposition of the study when the principal investigator (or faculty sponsor in the case of a student project] leaves the institution.

6. **VULNERABLE POPULATIONS:** Please note that there are special requirements for the inclusion of vulnerable populations (i.e. children and minors, prisoners, pregnant women and human fetuses, and cognitively impaired) in research. You may not enroll or otherwise include an individual who is or becomes a member of a vulnerable population while enrolled in the research if that vulnerable population has not already been approved by the IRB for enrollment. For additional information on the requirements for including vulnerable populations in research, please refer to http://research.iu.edu/rschcomp/hmpg.html .

Note: SOPs exist covering a variety of topics that may be relevant to the conduct of your research. For more information on the relevant policies and procedures, go to http://research.iu.edu/rschcomp/hmpg.html.

You should retain a copy of this letter and any associated approved study documents (e.g. informed consent or advertisements) for your records. All documentation related to this study must be maintained in your files for audit purposes for at least three years after closure of the research; however, please note that research studies subject to HIPAA may have different requirements regarding file storage after closure. Please refer to the project title and number in future correspondence with our office. Additional information is available on our website at http://research.iu.edu/rschcomp/hmpg.html. Please contact our office if you have questions or need further assistance.

Thank you.

1 | IUB Human Subjects Office | Carmichael Center, L03 | 530 E. Kirkwood Avenue | Bloomington, IN 47408-4003 | (812) 855-0945 | iub_hsc@indiana.edu

Appendix C: Confirmation of Participation

3/11/2009

Todd Foster
P.O. Box 3828
Majuro, MH 96960
625-2561 or 455-3368
tlfoster@indiana.edu

To participating private/public schools:

Hello. I am pleased to announce that my project, “A Nutritional and Anthropometric Assessment of Marshallese School Children”, has received full approval from IU Human Subjects, the RMI Human Subjects Council, and the Ministry of Health. I am currently training a research assistant and will be recruiting participants for the study at Majuro Cooperative School next week.

This letter is being sent to ask you to prepare a few things. First, I would like confirmation that your school is still willing to participate in this research study. Whether it is a letter, a phone call, an email, or a friendly conversation, I just want to ensure that you are willing to participate.

Second, in order to give parents and / or guardians a chance to get fully informed on the details of the project, I am asking when your next PTA meeting will be. I have prepared a ten minute presentation that discusses what the goals of the project are, what information we will be collecting and the benefits of the study. Please let me know when I can come and present the project to the PTA for your school.

Third, I would like to know what period of time would be most beneficial for your school and its students to participate. I am still planning on coming to your school during regular school hours, but the days of data collection will fall on Tuesdays and Thursdays for the rest of the 2009 Spring school semester. My research assistant and I would like to know what weeks and hours you would prefer for us to visit.

Again, I truly appreciate any correspondence and the patience that you have afforded the development of this project. My contact information is listed above and feel free to contact me to discuss the project or any questions you may have.

Sincerely,

Todd Foster

Appendix D: PTA Meeting Presentation Summary and Guidelines

PTA Meeting Presentation Summary and Guidelines

I) Introduction

2006 Pilot Study Results

II) Discussion of the Project's Goals

A) Updated nutritional assessment of children living on Majuro

1) New growth charts have been completed (WHO 2007 and CDC 2000)

2) Last full scale nutritional assessment was in 1991 by Julia Alfred

3) Pilot studies completed by Palafox, Gittelsohn, and Gammino

B) Comparison of Public and Private School children

C) Development of a Marshallese growth chart

D) Future directions of the research

1) Build upon Palafox, Gittelsohn, and Gammino research

2) Comparison to outer islands

3) Investigation into dual-malnutrition, nutrition transition, and connections to chronic diseases

III) Procedures to be Used

A) Questionnaires – completed by parents, mailed and to be completed at their leisure

B) Anthropometric Measurements – body measurements and quick explanation

C) Nutritional Recall information – what has your child consumed in the last 24 hours

D) Access to your child's yellow card

1) Need access to view date of birth, place of birth, weight at birth, birth mother's name, father's name, immunization administration dates, Vitamin A administration dates, and weight tracking data

2) Separate form will be administered to view this private health information

E) 20 minutes for each child

IV) Safety of the Participants in the Study

A) De-identified information to ensure confidentiality

B) Data collection will be completed in a private location at each school

C) Criminal history background check is provided

D) Besides Informed Consent, assent will be read to each child to ensure their active participation

V) Risks of Participating in the Study

A) Loss of Confidentiality- discuss who will get to see the information

B) Anthropometric tool scratching

C) Child's feelings regarding the study (i.e. being touched, feelings of insecurity)

D) Parent's feelings regarding their child's defined nutritional status

VI) Benefits of Participating in the Study

A) Personal benefits

1) Parents will be offered a complete assessment regarding their child

2) Attempting to show a need for Primary Public School Lunch Program

3) A population specific growth chart will assist pediatricians working in the RMI

B) Research benefits

1) Examination of child and adolescent growth in RMI, Micronesia, and Pacific

2) May lead to the exploration of the development of chronic diseases such as type II diabetes

VII) Informed Consent Statements and Authorization of Release of Personal Health Information (Emphasize envelopes!)

A) You can sign the informed consent statement and the Authorization of Release of Personal Health Information now

B) You can write contact information to request a meeting to discuss the project with me in more detail

C) If you and your child do not want to participate in this study, please return the informed consent and PHI documents unsigned in the envelope provided

Appendix E: Informed Consent (Marshallese Copy Available Upon Request)

Indiana University-Bloomington Informed Consent Statement

Nutritional and Anthropometric Assessment of Marshallese School Children

Information Regarding the Study:

You are invited to participate in a research project that will conduct a nutritional and anthropometric assessment of children attending primary schools on Majuro Atoll. Children attending first through eighth grades in both public and private schools are being sought for this project. The goals for this project include the creation of a Marshallese growth chart, an updated nutritional assessment of children living on Majuro, and a comparison of the nutritional status between public and private school children on Majuro. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Todd Foster, Indiana University-Bloomington. Four types of information will be collected from 720 children and their parents agreeing to participate in this project. First, a questionnaire will be disseminated to legal guardians who allow their child's participation. These questionnaires, which include 29 questions, involve information about the child and can be filled out and returned to the principle researcher at the legal guardian's leisure. These questionnaires should take you about ten minutes to complete. This information includes the immunization history of the child, how much money the legal guardian(s) earns, breastfeeding with the child, and other personal information. Second, your child's MOH issued yellow card will be viewed so that date of birth, place of birth, weight at birth, birth mother's name, father's name, immunization administration dates, Vitamin A administration dates, and weight tracking data can be recorded. This information will be used in the comparison between private and public school children as well as selecting children for the construction of the Marshallese growth chart. Once you agree to participation, these questionnaires will be sent to you by mail. In addition to this consent form, you will be asked to sign an 'Authorization for the Release of Health Information' form. If you do not want this health information viewed but still would like to participate in this research project, you and your child may do so and do not have to sign the 'Authorization of the Release of Health Information' document. Third, a 24-hour dietary recall interview will be randomly conducted with every third child participating in order to gather information on the types and amount of food eaten by the child in the previous 24 hours to get a sense of the type of nutrients and calories children are consuming. Fourth, body measurements will be conducted on every child participating. These measurements include height, weight, arm and elbow thickness, and skin folds on the back, arm and stomach. These measurements can be used to make assessments about the child's growth and development. 24-hour dietary recall interviews and anthropometric measurements will be collected from the child in a private room during school hours with a female, Marshallese assistant present. Before any data is collected with your child, they will be read and asked to sign an assent form that ensures their right and choice to participate in the study. The 24-hour dietary recall and anthropometric measurements, combined, should take about twenty minutes to complete with your child.

Risks of Taking Part in the Study

It is understood that the questionnaires may ask for information that some individuals consider private. All questionnaire, health information, body measurement, and interview data collected with this returned informed consent statement will be kept private and secured with the principle investigator. In addition, no identifying title (i.e. names) shall be kept with the collected data. Even with these safeguards put in place, there is a possibility that you and your child's personal information could be viewed by other people. Every effort will be made to keep your personal information confidential.

Body measurements are considered a non-invasive data collection technique and does not pose any serious risk to the child being measured. Even though this technique is considered non-invasive, some risks are still involved. First, minor scratching could occur on the child's skin if they were to move quickly while the tool is in use. Second, body measurements involve having the child touched by the principal investigator and having them stand, sit, or extend their limbs in various positions. This may make the child feel uncomfortable. Third, measurements such as weight may possibly cause the child anxiety regarding issues involving body size, weight, and body image.

Finally, as this project is assessing the nutritional status of your child, you may learn that your child is classified as 'underweight' or 'undernourished'. It is important to understand that this classification may not be a reflection of you as many health issues can influence the nutritional status of your child. If your child is classified as 'underweight' or 'undernourished', the principal investigator may recommend that you have your child's pediatrician or health care professional complete a follow-up for a more accurate assessment of your child's health.

Benefits to Participating in the Study

This project is attempting to collect nutritional and body measurement information from at least 720 children. Due to the number of children sought for this project, no compensation will be offered.

The expected differences between the public and private school children will be used as evidence to help support the initiation of a school lunch program for the children attending public schools on Majuro. Furthermore, the information collected here will assist in the construction of a population specific growth chart that will benefit pediatricians and other health care providers attempting to treat and complete research in the Republic of the Marshall Islands.

Another purpose of this project is to explore reasons for the high prevalence of undernutrition among children and type II diabetes, cardiovascular disease, and obesity among adults living in the Marshall Islands. The information collected in this research project may help initiate such a project in the summer of 2010.

Alternatives to Taking Part in the Study:

Please understand that if you or your child does not want to participate in this research project, you both have the alternative, which is not to participate. If you have a child attending Majuro Cooperative School and do not want them participating in this study, you have the right to make that decision. If your child is a student of Todd Foster, your choice will not affect your child's grade in any manner.

Confidentiality

Efforts will be made to keep your personal information (i.e. information collected in questionnaires, MoH Yellow Cards, nutritional recall interviews, and anthropometric measurements) private. We cannot guarantee absolute confidentiality. Your personal information will be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published. This data will be kept separate from you and your child's identifying information as a subject number will be assigned to each child's information and measurements. This information will be stored in a locked filing cabinet in a private location. One year after the completion of the study, all personal information connecting the participant to the data will be destroyed. Data regarding the growth and development of Marshallese children will be kept indefinitely for future health research and use. Some organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the IUB Institutional Review Board or its designees, the study sponsor, the RMI Ministry of Health, the RMI Ministry of Education, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections (OHRP).

Participation

Participation in this study is strictly voluntary and there is no cost to those who do participate. Participation in this study will not be allowed unless the appropriate signatures are provided on the next page. If you or your child do participate and want to withdraw from the study at any time, you are welcome to do so. If withdrawal from the study is selected before data analysis occurs, your data will be destroyed.

Contact

If you were to have additional questions regarding your own and your child's participation, the nature of the study, what is being done with your information, or have any further inquiries, please contact Todd Foster (tlfoster@indiana.edu) at PO Box 3828, Majuro, MH 96960 or by phone at 455-3368. You may also contact Paul L. Jamison, the faculty sponsor of this project, at Indiana University-Bloomington, Department of Anthropology, Bloomington, Indiana 47405 or by phone at 011-1-812-335-1495

For questions about your rights as a research participant or to discuss problems, complaints or concerns about a research study, or to obtain information, or offer input, contact the IUB Human Subjects office, 530 E Kirkwood Ave, Carmichael Center, L03, Bloomington IN 47408, 011-1-812-855-3067 or by email at iub_hsc@indiana.edu

Consent

Please carefully read the following consent statements and sign where you agree to give permission.

I have read and understand the above information. I have received a copy of this form. I agree to my child's participation in this study. Once this document is signed, please place it and any other signed documents into the accompanying stamped and addressed envelope and into the mail.

Date:

First parent or guardian's Printed Name:___________________________________

First parent or guardian's Signature:_______________________________________

Date:

Second parent or guardian's Printed Name (if applicable):____

Second parent or guardian's signature (if applicable):____

Name of Child:____

Date:

Printed Name of Person Obtaining Consent:________________________________

Signature of Person Obtaining Consent:____________________________________

Contact Information (Please include your address, phone number, email, or any preferred method of contact):

____

____

Assigned Subject Number 08-________________

Appendix F: Child Assent (Marshallese Copy Available Upon Request)

IRB Study # 08-13511
Indiana University Bloomington Child Assent To Participate in Research
Nutritional and Anthropometric Assessment of Marshallese School Children

We are doing a research study. A research study is a special way to learn about something. We are doing this research study because we are trying to find out more about how kids like you grow and develop**.** We would like to ask you to be in this research study.

You are being asked to be in this research study because you are a kid who is enrolled in a primary school on Majuro.

We want to tell you about some things that will happen if you are in the study. This study will take place at your school. We think it will last for twenty minutes**.**

If you want to be in this study, here are the things that we may ask you to do. We might ask you some questions about what you ate in the last day and will take some measurements of your body.

Sometimes bad things happen to people who are in research studies. These bad things are called "risks." The risks of being in this study might be some scratches from the measurement tools**.** To keep from scratching you, I am going to ask that you hold very still during the measurements. Another risk in this research study involves your personal information. There is the possibility that other students, parents, or researchers may hear or see your personal information, which includes your Yellow card health information, body measurements and dietary recall.

Sometimes good things happen to people who are in research studies. These good things are called "benefits." The benefits of being in this study might be helping doctors and scientists understand how you grow so we can take better care of your health.

We don't know for sure if you will have any benefits. **If applicable:** We hope to learn something that will help other people some day.

You will not get any money for being in this research study.

If you have any questions about this study, you can ask your parents or guardians or your doctor, or Mr. Todd. Also, if you have any questions that you didn't think of now, you can ask your parents to contact Mr. Todd with your question.

If you don't want to be in this study, you don't have to. It's up to you. If you say you want to be in it and then change your mind, that's OK. All you have to do is tell us that you don't want to be in it anymore and we will stop. No one will be mad at you or upset with you if you don't want to be in it. If you are a student of Mr. Todd and choose not to be in the study, it will not affect your grade in any way.

If I write my name on the line below, it means that I agree to be in this research study.

__________________________________ _________________

Subject's Signature Date

____

Subject's Name

__________________________________ __________________

Signature of person obtaining assent Date

____

Name of person obtaining assent

Subject # 08-____________________

Appendix G: Post-Anthropometric Measurement Letter to Parent or Guardian (Marshallese Copy Available Upon Request)

Dear Parent or Guardian:

Hello and Iakwe! I want to thank you and your child for participating in the Indiana University sponsored project (#08-13511), A Nutritional and Anthropometric Assessment of Marshallese School Children. By receiving this letter, you have already signed the informed consent form and I have met with your child. As stated previously, not only was your permission sought, but your child was read an assent form to obtain their permission in order to participate in this study. My research assistant and I have interviewed your child and/or collected body measurements.

Again, we are collecting four types of data in this project. These include body measurements and possibly a 24-hour dietary recall interview with your child, a 29-question questionnaire to be filled out by you, the parent or guardian, and recording information located on your child's yellow card at their school or the hospital. That is the purpose of this letter.

Enclosed, you will find the questionnaire and a Release of Personal Health Information (RPHI) form. For those parents or guardians that returned their copy of the informed consent form, I have enclosed a copy for your records. Please fill the questionnaire and RPHI out at your leisure and return them in the addressed, stamped envelope that was sent home with your child. Remember, if you prefer that we do not record any information from your child's yellow card, you do not have to sign the RPHI form. Simply fill out the questionnaire, place it back in the envelope with the unsigned RPHI, and mail it back to us. We hope you will allow us to look at this information as it will let us verify birthdates and examine the child's growth from birth to age five. If you have any questions, feel free to contact me with the information below or located on your copy of the informed consent form. Thank you.

Sincerely,

Todd Foster
Principal Investigator
A Nutritional and Anthropometric Assessment of Marshallese School Children (08-13511)
455-3368
tlfoster@indiana.edu

Appendix H: Interview Questions

1) How do you define the word nutrition? What do you think is included in "good" nutrition?

2) What meals do you usually have at your home? American meals usually include breakfast in the morning, lunch at mid-day, and dinner in the evening. Do you consider your home to follow a different standard?

3) What meal(s) does your family usually eat together?

4) Do you consider these meals…

5) Where are meals prepared in your home?

6) When you at dinner last night, with how many people did you eat your meal?

7) Is there an order to who eats during the meal?

8) What is your attitude towards what your children eat? (Clarification: Is it that they are little adults and will eat if they are hungry? Or Is it that we, as parents, need to ensure that kids eat right even if they don't want to?

9) Do your children get to choose which foods they want to eat?

10) Do your children…

Eat food when they are hungry.

Have to wait to eat at meal times.

11) What foods do your children normally ask for?

12) What are two of their favorite foods?

13) What are two foods they hate?

14) Think about food ingredients you consider traditionally Marshallese? Name five of these.

15) Think about what prepared dishes you consider traditionally Marshallese. Name five of these.

16) How do you preserve your foods?

17) Do you ever exchange food items with other families?

If yes, how often

When do you exchange?

What do you exchange?

18) How many times a week does your family eat at a restaurant?

19) How many times a week do you eat at a restaurant without your family?

20) Tell me a meal (specific dishes) your family has consumed over the last day?

Appendix I: Parent Questionnaire

Subject Number______________________________ Birth date_______________________

Please answer the following questions to the best of your ability. If you have a question or problem regarding one of the inquiries, please feel free to discuss them with me. Where appropriate, please circle the correct answer. All information will be kept confidential.

1) Ethnicity of the child (please circle all that apply):

Marshallese American Japanese Korean Chinese

Taiwanese Federated States of Micronesia Other____________________

2) What is the child's mother's age? ____________ Father's age? ____________

3) On what island was your child born? = Kwar lotak ia, Kwalok ene im aelon?

____

4) Where (island / city) did your child live in the first 5 years of their life?

____

5) How many people are in your household? = Jete armej ilo mweo mom?

____

6) How many of these people are children?

____

7) How many people are working in your household? = Jete ri-jarbal ilo mweo mom?

____

8) What is the amount of income per month supporting the home in which the child lives? (This includes the legal guardians and any other individuals living in the home who are bringing money into the home.) (please circle)

$ 0 – 25 / month $ 30 – 80 / month $ 85 – 140 / month

$ 150 – 200 / month $ 210 – 260 / month $ 270 – 320 / month

$ 325 or more / month

9) If this child was not feeling well, what kind of treatment would you seek? (Please circle)

A) Visit a doctor practicing American medicine

B) Visit a doctor practicing Marshallese medicine

C) Visit the hospital

D) Other ______________________________

10) Since birth, this child had an illness or infection

A) 0 – 2 times / year

B) 3 – 4 times / year

C) 5 – 6 times / year

D) 7 – 8 times / year

E) 9 or more times / year

11) Since birth, this child has been taken to the hospital

A) 0 – 2 times / year

B) 3 – 4 times / year

C) 5 – 6 times / year

D) 7 – 8 times / year

E) 9 or more times / year

12) Over the past two weeks, has the child had diarrhea, a cold or respiratory infection, or a fever:

A) 0 – 2 times

B) 3 – 4 times

C) 5 – 6 times

D) 7 – 8 times

E) 9 or more times

13) Over the past year, has the child had diarrhea, a cold or respiratory infection, or a fever:

A) 0 – 2 times

B) 3 – 4 times

C) 5 – 6 times

D) 7 – 8 times

E) 9 or more times

14) Did you breastfeed this child?

Yes No Don't know

15) How long did you breastfeed this child?

A) 1-3 months

B) 4-6 months

C) 7-9 months

D) 10-12 months

E) More than a year

16) At what time did you begin feeding this child with a bottle?

A) 1-3 months

B) 4-6 months

C) 7-9 months

D) 10-12 months

E) More than a year

17) At what time did you begin introducing solid foods (i.e. baby food, mashed pandanus, breadfruit, rice jukjuk)?

A) 1-3 months

B) 4-6 months

C) 7-9 months

D) 10-12 months

E) More than a year

18) How frequently do you notice your child to wash his / her hands every day?

A) Never

B) Once or twice a day

C) Three or four times a day

D) Five or more times a day

19) From which source does your water come?

A) Water catchment

B) Well

C) Majuro City Water

D) Unsure

E) Other________________________

20) Does anyone smoke in the household where the child lives?

Yes No

21) Did the mother smoke before the pregnancy?

Yes No Don't know

22) Did the mother smoke during the pregnancy?

Yes No Don't know

23) Did the mother smoke after birth and during breastfeeding?

Yes No Don't know

24) How many hours of sleep does this child receive at night on average?

A) 2-3 hours

B) 4-6 hours

C) 7-9 hours

D) 10 or more hours

25) Where was your child delivered?

In the household At the hospital Other__________________________

Todd Foster

tfost003@stvincent.org

Education:

2008 – 2015	Ph.D., Indiana University, Bloomington, Indiana Ph.D. program in Biological Anthropology
2004-2008	Master of Arts, Indiana University, Bloomington, Indiana Anthropology, May 2008 Major: Biological Anthropology Minors: Cultural Anthropology, Medical Science
2001-2004	Bachelor of Arts, Indiana University-Purdue University of Indianapolis, Indianapolis, Indiana, May 2004 Major: Anthropology Minor: Human Biology

Research Experience:

2011-Present *Research Scientist*, St. Vincent Hospital, Indianapolis, Indiana

-Assisted staff and resident physicians and other hospital staff with their research curriculum and project completion
-Analyzed data and assisted in the completion of manuscripts
-Conducted personal research projects and goals

2008-2009 *Principal Investigator*, Nutritional and Anthropometric Assessment of Marshallese School Children, Majuro, Republic of the Marshall Islands

-Organized informational meetings with government organizations, school administrations, and parents / guardians of children attending local schools
-Collected anthropometric data (stature, sitting height, weight, elbow breadth, MUAC, skinfolds) on 605 Marshallese school children ranging from kindergarten to eighth grade

2006 *Research Assistant and Physical Education Instructor* for Dr. Ralph Harris, The Diabetes Wellness Center, Ministry of Health, Majuro, Republic of the Marshall Islands

-Collected anthropometric data (height, weight, waist / hip circumference) and physiology measurements (blood pressure, *Ha1c* levels)
-Formulated and taught weekly exercise and weight lifting routines for participants in the diabetes research study
-Advised participants on their weekly glucose levels and dietary habits

2004-2005 *Research Assistant and Experimenter* for Dr. Erich Janssen, The Kinsey Institute: Research in Sex, Gender, and Reproduction

-Conducted experiment sessions with subjects
-Entered and examined data dealing with physiological measurements

Instruction in Pedagogy

Spring 2007 Anthropology-A521 Internship in Teaching Anthropology

-Participated in peer-evaluated teaching tutorials
-Researched proper methods in selecting text books and developing tests
-Developed a course entitled "Populations of the Pacific" which examines biological, linguistic, archaeological, and cultural anthropology issues in the Pacific

Teaching Experience:

Fa. 2010 *Adjunct Faculty Instructor*, B480 Human Growth and Development, Indiana University-Purdue University of Indianapolis

-Explored the physical processes of growth and development from a biocultural perspective
-Led students in seminar discussion of relevant research papers in the topics of growth and development
-Instructed students in the collection, analysis, presentation, and interpretation of individualized and population growth data

Fa. 2010/07/06 *Associate Instructor*, B301 Laboratory Methods in Bioanthropology, IU-Bloomington

-Reviewed Bioanthropology topics and instructed students in data collection methods used in the field
-Guided student research projects including data analysis, interpretation and write-up of reports

Sp. 2010/08 *Associate Instructor*, B200 Introduction to Bioanthropology, Indiana University, Bloomington

-Introduced students to a general survey of biological anthropology, including: evolutionary theory, genetics, primate morphology and social behavior, human evolution, and human biology/osteology and behavior.

Su. 2009 *Adjunct Faculty Instructor*, SCI 120-1 Introduction to Biology, College of the Marshall Islands, Republic of the Marshall Islands

-An introductory biology course for non-majors that addressed the nature of science, biological organization and emergent properties of life, bioenergetics, cell reproduction, principles of genetics, and evolution as a mechanism of change in biology.

Sp. 2009/ Fa. 2008 *Middle School Health and Math Instructor*, Majuro Cooperative School, Republic of the Marshall Islands

-Developed Health curriculum for Majuro Cooperative Middle School
-Taught sixth, seventh, and eighth grade students health concepts including nutrition, anatomy and physiology, growth and development, sexual education, life choices, and hygiene.
-Instructed students in math concepts including adding, subtracting, multiplying, and dividing fractions; algebraic equations; simple geometry and arc equations.

Su. 2007 *Associate Instructor*, A105 Evolution and Prehistory, IU-Bloomington

-Instructed students in concepts dealing with evolution and archaeology with a particular focus on the emergence of *Homo sapiens*
-Explored topics such as human cells and genetics, primates, the paleontological record, and the material culture creations of ancient people from stone tools to pyramids

Sp. 2007 *Reader* for Dr. Della Cook, B200 Bioanthropology, IU-Bloomington

-Graded and maintained a log of weekly assignments, laboratory exercises, and exams
-Held weekly office hours assisting students with learning class material and completing class assignments

Su. 2006 *Instructor*, Reading and Sexual Education, English Language Institute, Ministry of Education, Majuro, Republic of Marshall Islands

-Taught reading instruction techniques
-Created culturally sensitive sex education curriculums with instructors

Sp. 2006 *Associate Instructor*, L113, Biology Laboratory, Department of Biology, IU-Bloomington

-Assisted students completing biology experiments that complimented an introductory Biology course
-Led weekly one hour discussion sections to review lab experiments, introduced background information, and guide student development

Guest Lecturer:

April 2014 “Protocol Development and Basic Statistics” Family Medicine, Internal Medicine, and Pharmacology Resident Lectures, St. Vincent Hospital, Indianapolis

Aug. 2012 “Statistics for the Non-Statistician: Learn to drive, don’t worry about the mechanics.” Ob/Gyn Resident Lectures, St. Vincent Women’s Hospital

Sp. 2007 “Drinking, Suicide, and Modernization: The changes among Marshallese and their movement into a globalized society.” E354 Cultures of the Pacific, Indiana University-Purdue University of Indianapolis, Instructor: Dr. Jeanette Dickerson-Putnam

Fa. 2006 “Collecting Action Figures and Comic Books: Finding their political and cultural economy.” E382 Memory and Culture, Indiana University-Bloomington, Instructor: Dr. Paula Girshick

Work Experience:

2009 *Residential Coordinator*, College of the Marshall Islands, Majuro, Republic of the Marshall Islands

-Directed successful placement, engagement and supervision of students living
-Conducted orientation for all new residents
-Formulated and implemented dormitory living and safety policies

2003-2004 *Environmental Control Technician* for Marion County Health Department-Mosquito Control, Indianapolis, Indiana

-Provided community service and education in Marion County on the breeding techniques of mosquitoes
-Collected biological samples of mosquitoes, larvae and pupae

Membership In Professional Organizations:

American Association of Physical Anthropologists
Human Biology Association
Society of the Sigma Xi

Grants and Awards:

2012 St. Vincent Foundation Grant, St. Vincent Hospital, Indianapolis

2010 Grant-in-Aid, University Graduate School, IU-Bloomington

2006 David C. Skomp Summer Dissertation Research Award, Dept. of Anthropology, IU-Bloomington

Publications:

2014 Bivins HA, Butler ES, Foster TL, Pyle R, Sumners JE. 2014. Congenital Abdominal Aortic Aneurysm. *Ultrasound in Obstetrics & Gynecology* 43(2): 233-4.

2013 Foster TL, Addleman R, Moore ES, Sumners JE. 2013. Robotic-Assisted Prophylactic Transabdominal Cervical Cerclage in Singleton Pregnancies. *Journal of Obstetrics and Gynaecology*. 33: 821-2.

2013 Martin J, Moore ES, Foster TL, Sumners JE. 2013 Transabdominal cerclage placement in patients with prior uterine incisions: risk of scar disruption. *Journal of Obstetrics and Gynaecology*. 33(7): 682-4.

2012 Moore ES, Foster TL, McHugh K, Addleman RN, Sumners JE. 2012. Robotic-assisted transabdominal cerclage (RoboTAC) in the non-pregnant patient: A case series and review of the literature. *Journal of Obstetrics and Gynaecology* 32 (7): 643-7.

2011 Foster TL, Moore ES, Sumners JE. 2011. Operative complications and fetal morbidity encountered in 300 prophylactic transabdominal cervical cerclage procedures by one obstetric surgeon. *Journal of Obstetrics and Gynaecology* 31 (8): 713-7.

Meetings Presentations:

2014 Meador T, Henein M, Foster T. Latent Tuberculosis: Utilizing prenatal visits to identify women at increased risk via appropriate screening technique. Poster presentation at the AAFP Global Health Workshop, San Diego, California, September 2014.

2013 Foster TL, Escobar LF, Sumners JE. Cognitive Developmental Outcomes of Triplets, Poster presentation at the Society for Maternal-Fetal Medicine's 33rd Annual Meeting, San Francisco, California, February 14-17, 2013.

2012 Sumners JE, Foster TL, Addleman RN, and Moore ES. Robotic-Assisted Prophylactic Transabdominal Cerclage in Singleton Pregnancies. Central Association of Obstetricians & Gynecologists Meetings, October 17th – 20th, Chicago, Illinois.

2011 Foster TL. A Nutritional Assessment of Marshallese School Children: Issues involved in applying Anthropology in order to support social change. American Association of Physical Anthropologists Meetings, April 12th – 16th, Minneapolis, Minnesota.

2011 Foster TL, Roditis M, and Jamison PL. What's in a Number?: How WHO and CDC reference data differentially categorize undernourished vs overnourished populations. Human Biology Association Meetings, April 12th – 16th, Minneapolis, Minnesota.

2008 Foster TL, Graham B, de Brum I, and Ogborn K. Probable Effects of Nutrition on Health and Performance of Marshallese School Children. Human Biology Association Meetings, April 9-10th, Columbus, Ohio. Poster